Canadian Manuscript Report of
Fisheries and Aquatic Sciences
No. 1559

April 1980

THE WALLEYE, *Stizostedion vitreum* (MITCHILL), SPORT FISHERY ON MOSQUITO CREEK, NORTHWEST TERRITORIES, 1973-78

by

M.R. Falk, D.V. Gillman and C.J. Read

Western Region
Department of Fisheries and Oceans
Winnipeg, Manitoba R3T 2N6

This is the 23rd Manuscript Report
from the Western Region, Winnipeg

© Minister of Supply and Services Canada 1980

Cat. no. Fs 97-4/1559 ISSN 0706-6473

TABLE OF CONTENTS

	Page
ABSTRACT/RESUME	iv
INTRODUCTION	1
DESCRIPTION OF THE STUDY AREA	1
DESCRIPTION OF FISHERY	1
MATERIALS AND METHODS	2
Field	2
Laboratory	3
RESULTS AND DISCUSSION	3
Creel census	3
Size composition	4
Age determination	4
Age composition	5
Growth	5
Mortality	6
Sex ratio and maturity	6
Fecundity	6
Spawning migration	7
Upstream migration	7
Downstream migration	7
Spawning period	7
Environmental variables	8
Population estimate	8
Post-spawning movements	8
Tag returns	
Dispersal	9
Summer distribution	9
Homing behavior	9
IMPLICATIONS FOR MANAGEMENT	10
RECOMMENDATIONS	10
ACKNOWLEDGMENTS	11
REFERENCES	11

LIST OF FIGURES

Figure		Page
1	Map of the North Arm of Great Slave Lake showing the location of Mosquito Creek	14
2	Map of Mosquito Creek and immediate vicinity showing the fish fence location	15
3	Comparison of creel census results by year from Mosquito Creek, 1973-78	16
4	Length-frequency distributions by capture method for walleye from Mosquito Creek, 1973-78	17
5	Length-frequency distributions for walleye caught by angling from Mosquito Creek, 1973-78	18
6	Length-frequency distributions for walleye caught by fish fence from Mosquito Creek, 1974-75	19
7	Age-frequency distributions by capture method for walleye from Mosquito Creek, 1973-78	20

LIST OF FIGURES cont'd

Figure		Page
8	Age-frequency distributions for walleye caught by angling from Mosquito Creek, 1973-78	21
9	Age-frequency distributions for walleye caught by the fish fence from Mosquito Creek, 1974-75	22
10	Comparison of scale age to dorsal spine/fin ray age for walleye from Mosquito Creek, 1978	23
11	Comparison of growth curves for male and female walleye from Mosquito Creek, 1973-78 (Fitted by eye)	24
12	Comparison of the growth curve of walleye (sexes combined) from Mosquito Creek, 1973-78, to other walleye populations in North America	25
13	Catch curves and annual mortality rates for walleye caught by angling from Mosquito Creek, 1973-78	26
14	Catch curves and annual mortality rates by capture method for walleye from Mosquito Creek, 1973-78	27
15	Upstream and downstream movements of walleye in Mosquito Creek as determined by fish fence counts, 17 May to 12 June, 1974	28
16	Distribution and apparent movement patterns of mature walleye in the North Arm of Great Slave Lake as determined from walleye tagged in Mosquito Creek, 1973-78	29

ABSTRACT

Falk, M.R., D.V. Gillman, and C.J. Read. 1980. The walleye, *Stizostedion vitreum* (Mitchill), sport fishery on Mosquito Creek, Northwest Territories, 1973-78. Can. MS Rep. Fish. Aquat. Sci. 1559: v + 29 p.

Mosquito Creek, situated on the North Arm of Great Slave Lake, supports a popular walleye sport fishery in the early spring for residents of Yellowknife, Northwest Territories. The spawning population of walleye in Mosquito Creek was studied from 1973 to 1978 through a creel census and biological sampling program which included fish fence (weir), gillnet, hoop net, fyke net and tagging operations.

The fishing season on Mosquito Creek extended from as early as 6 May to as late as 7 June for an average of 20 days. The number of anglers frequenting Mosquito Creek over the fishing season ranged from 105 in 1973 to 295 in 1977. The total retained catch of walleye ranged from 282 in 1975 to 567 in 1973 (mean = 410). Catches of walleye per angler-day and per angler-hour averaged 1.70 and 0.64, respectively and have remained relatively constant from 1975 to 1978.

Mean length of walleye was 427 mm and mean weight was 911 g. Females were longer (461 mm) and heavier (1174 g) than males (419 mm; 819 g). Mean age of walleye was 10.5 yr (males = 10.1 yr; females = 11.6 yr). Females appeared to grow faster than males after age 8. The oldest fish caught was at least 24 yr from dorsal spines/pelvic rays. Annual mortality rates ranged from 42 to 53 percent for all capture methods. Female to male sex ratios ranged from 0.11:1 for the angled catch to 0.69:1 for the fish fence sample. Sexual maturity was first reached at age 6 for males and age 8 for females. Fecundity ranged from 15,813 to 81,061 eggs·kg^{-1} (mean = 45,037 eggs·kg^{-1}).

The walleye spawning migration in Mosquito Creek was coincident with increasing water temperature and was modified by weather conditions. Males reached the spawning ground first and remained the longest; females arrived later, spawned quickly and left shortly after. Both movement into the creek and spawning occurred during the evening and at night. Mean number of days spent upstream was 7.0 days for males and 2.9 days for females. The spawning population of walleye utilizing Mosquito Creek in 1975 was estimated at 5,600. For 62 tagged walleye the mean distance travelled was 69 km (range 23-127 km). Post-spawning dispersal was both rapid and complete. Some walleye migrated in discrete groups to summer feeding areas and homed to Mosquito Creek in successive years.

Creel census and biological results indicate that the spring sport fishery on Mosquito Creek is not having a serious or detrimental effect on walleye in the area. Periodic monitoring is recommended to assess changes in angling pressure, angler harvest and biological characteristics of walleye.

Key words: angling; catch composition; catch/effort; sport fishing statistics; exploitation; fishery management; monitoring; population structure; size distribution; tagging.

RESUME

Falk, M.R., D.V. Gillman, and C.J. Read. 1980. The walleye, *Stizostedion vitreum* (Mitchill), sport fishery on Mosquito Creek, Northwest Territories, 1973-78. Can. MS Rep. Fish. Aquat. Sci. 1559: v + 29 p.

La pêche sportive au doré, au début du printemps, dans le Mosquito Creek, un affluent du Bras Nord du Great Slave Lake est très populaire auprès des résidants de Yellowknife (Territoires du Nord-Ouest). De 1973 à 1978 on a étudié la population de doré du Mosquito Creek pendant le frai en effectuant une étude sur le rendement de la pêche et un programme d'échantillonnage biologique donnant lieu à l'utilisation de fascines, de trubleaux, de filets maillants et au marquage de poissons.

La saison de pêche dans le Mosquito Creek dure en moyenne 20 jours; elle se situe entre le 6 mai et le 7 juin. Quant au nombre de pêcheurs à la ligne se rendant pendant la saison de pêche, il y en avait 105 en 1973 et 295 en 1977. Le nombre total de dorés retenus est passé de 567 en 1973 à 282 en 1975 (une moyenne de 410). Les prises de doré par pêcheur par jour et par heure étaient en moyenne de 1.70 et 0.64, respectivement, et sont demeurées relativement stables de 1975 à 1978.

La taille moyenne des dorés était de 427 mm et le poids moyen, de 911 g. Les femelles étaient plus longues (461 mm) et plus lourdes (1174 g) que les mâles (419 mm; 819 g). L'âge moyen était 10.5 ans (les mâles = 10.1 ans; femelles = 11.6 ans). Dépassé l'âge de 8 ans, les femelles semblent croître plus rapidement que les mâles. En se basant sur l'épine dorsale et les rayons pelviens, le plus vieux poisson pêché avait au moins 24 ans. Compte tenu des résultats pour toutes les méthodes de pêche, le taux de mortalité annuel varie entre 42 et 53%. Moins de femelles que de mâles ont été prises par les sportifs (0.11:1) et grâce aux filets (0.69:1). Les mâles atteignent la maturité sexuelle à 6 ans et les femelles, à 8 ans. La fécondité varie de 15,813 à 81,061 oeufs·kg^{-1} (moyenne = 45,037 oeufs·kg^{-1}).

La migration de frai du doré dans le Mosquito Creek coincidait avec le réchauffement de la température aquatique et était affectée par les conditions atmosphériques. Les mâles atteignaient la frayère les premiers et y demeuraient plus longtemps que les femelles, qui frayaient rapidement. La remontée du ruisseau et le frai se faisaient durant la soirée et la nuit. La durée moyenne du séjour en amont était de 7.0 jours pour les mâles et de 2.9 jours pour les femelles. En 1975 on a estimé à 5,600 spécimens la population de dorés ayant frayé dans le Mosquito Creek. La distance moyenne parcourue par 62 dorés

étiquetés était de 69 km (de 23 à 217 km). La dispersion après le frai était rapide et complète. Certains dorés ont émigré en groupes vers des zones d'alimentation estivales, puis sont revenus au Mosquito Creek dans les années suivantes.

Les statistiques de pêche et les résultats d'études biologiques démontrent que la pêche sportive se pratiquant le printemps dans le Mosquito Creek n'a pas d'effets graves ou nuisibles sur le doré de la région. Une surveillance périodique est recommandée afin d'évaluer les changements dans l'intensité de cette pêche, des prises et des caracteristiques biologiques du doré.

Mots-clés: pêche à la ligne; composition des prises; prises/effort; statistiques sur la pêche sportive; exploitation; gestion des pêches tailles; contrôle; structure démographique; distribution des tailles; étiquetage.

INTRODUCTION

In the Northwest Territories, walleye, *Stizostedion vitreum* (Mitchill), are confined to the Mackenzie River drainage and reach their northern distribution limit in the Mackenzie Delta (Scott and Crossman 1973). Despite this restricted distribution in the Northwest Territories, walleye is an important commercial and sport fish. Annual commercial production of walleye in the Northwest Territories is about 30,000 kg (65,000 lb) round weight, of which 11,000 kg (37%) is from Great Slave Lake (Moshenko et al. 1978). While anglers in 1974 rated walleye behind lake trout, Arctic grayling and northern pike as the species most sought after in the Territories (Topolniski 1975), considerable angler-effort is directed toward walleye around population centres such as Yellowknife and Hay River. Most angling for walleye occurs in the spring and summer months, when fish are concentrated during spawning and feeding migrations (Bond et al. 1978).

Published information on the biology and angler-harvest of walleye in the Northwest Territories is meager. Miller (1947), Rawson (1947, 1951) and Johnson (1975) provide some general information on walleye from Great Bear and Great Slave lakes. Reports by Hatfield et al. (1972a, 1972b), Stein et al. (1973a, 1973b), Jessop et al. (1973, 1974), Jessop and Lilley (1975) and Doran (1974), contain more comprehensive biological information on walleye from the Mackenzie River and many of its tributary streams. More recently, Falk and Dahlke (1975) and Bond et al. (1978) describe the walleye sport fisheries along the south shore of Great Slave Lake. Apart from these, and other scattered accounts, there are limited baseline data upon which to develop an effective sport fishery management program for walleye. Information contained in this report will therefore greatly enhance the existing data base and may be used, in conjunction with other sources of relevant information, to develop sport fishery management strategies appropriate to walleye in the Northwest Territories.

The present study was initiated in 1973 as a preliminary creel census and biological sampling survey to assess angling pressure and to determine the angler-harvest of walleye in Mosquito Creek. This survey indicated that Mosquito Creek was a spawning stream for walleye and an important recreational fishery. In 1974 and 1975 the scope of the study was expanded to include enumeration of the walleye population spawning in Mosquito Creek and more intensive tagging to determine the movements and distribution of walleye in Great Slave Lake. In 1976 and 1977 gillnetting was carried out in the North Arm of Great Slave Lake to determine the post-spawning distribution of walleye. The study continued in 1978 with further creel census, biological sampling and tagging.

This report provides a comprehensive summary of catch/effort and biological data collected on walleye from Mosquito Creek and vicinity during the period - 1973 to 1978; and presents recommendations for management and future study of the Mosquito Creek sport fishery.

DESCRIPTION OF THE STUDY AREA

Mosquito Creek (62°42'N; 116°5'W), empties into the North Arm of Great Slave Lake in the District of Mackenzie, Northwest Territories (Fig. 1). It is situated in an area constituting the northern fringe of the Mackenzie Lowlands, a continuation of the Great Central Plains (Rawson 1947). The surrounding region is generally low and flat with the exception of gentle hills and rock outcrops. Shallow lakes, swamps and muskeg are characteristic of the area. Black spruce is the dominant tree cover with scattered white birch. Shorelines exhibit heavy growth of willow, alder and sedges.

Mosquito Creek originates from Mosquito Lake (4.7 km^2) and drains an area of about 570 km^2. The creek drops from an elevation of 630 m above sea level at Mosquito Lake to 540 m above sea level at its mouth on Great Slave Lake. It is typical of brown-water muskeg drainages in the area with high spring runoff and minimal summer flows. Mosquito Creek can be divided into three distinct zones (Fig. 2). The upper zone, approximately 4 km in length, 6 m wide and 2-3 m deep, has a substrate of sand and scattered boulders. As it widens to about 25 m in the central zone, the creek becomes shallower (1-2 m) and the stream bottom gives way to sand and small (walnut-size) rocks. Numerous sedge-covered islands of the delta and a substrate of silt and hard clay pans constitute the third zone. In this zone the creek is about 1 km long, 25-40 m wide and 0.5-2 m deep.

The Mackenzie Highway crosses Mosquito Creek approximately 0.5 km below its outlet from Mosquito Lake and extends 116 km to Yellowknife (Fig. 2). Two culverts, situated side by side and each about 4 m in diameter, were installed in 1969 to allow the passage of water beneath the highway. The culverts create a 1-2 m drop on the downstream side, thus preventing the upstream passage of fish.

The timing of spring breakup in Mosquito Creek is variable and has been recorded as early as 5 May in 1973 and as late as 13 May in 1978. Usually, breakup occurs within the second week of May. Water temperatures in the creek vary from year to year with spring highs ranging from 7.8°C on 14 May 1976 to 9.7°C on 18 May 1977. However, water temperature usually ranges from lows of 1-2°C in the second week of May to 7-9°C in the fourth week of May. Stream flows determined in the central zone of Mosquito Creek from 22 May to 11 June 1975 averaged 4.6 $m \cdot sec^{-1}$ (range = 2.4-7.2). On 20 May of the same year analyses of water samples revealed pH of 8.02 and conductivity of 950 $umhos \cdot cm^{-1}$.

DESCRIPTION OF FISHERY

Prior to 1969 angling pressure on the Mosquito Creek walleye spawning population was apparently light as only residents of the immediate area, primarily the community of Rae, knew of or were able to gain access to the fishery. With completion of the Mackenzie

Highway to Yellowknife around the North Arm of Great Slave Lake, Mosquito Creek rapidly became a popular sport fishery. As angling pressure increased, concern was expressed in the early 1970's as to the possibility of over-exploitation of the walleye spawning population and possible adverse effects of the stream crossing. In 1974 daily catch and possession limits for walleye in the Northwest Territories were changed from 10 daily and 10 total to 5 daily and 10 total in response to concern over the Mosquito Creek and other spring walleye fisheries.

Angling on Mosquito Creek commences as soon as there is open water and continues for three to four weeks. Normally, peak angler activity occurs during the two weeks immediately following spring breakup. Angling usually continues until early June. However, angler-success for walleye declines rapidly as spawning is completed and walleye return to Great Slave Lake. Afternoons and evening are the times of day preferred by anglers. The numbers of anglers tend to increase during the afternoon and drop off during the early evening. Angling pressure increases after mid-day and continues into the late evening. Although walleye is the principal game fish caught by anglers, northern pike, *Esox lucius* Linnaeus, longnose sucker, *Catostomus commersoni* (Forster) and round whitefish, *Prosopium cylindraceum* (Pallas), are also caught in smaller numbers but tend to be released in favor of walleye.

From interviews it has been determined that 90 percent of the anglers frequenting Mosquito Creek in the spring are from Yellowknife. Angling occurs primarily from the mouth of Mosquito Creek to about 2.5 km upstream into the central zone (Fig. 2). Most anglers reach the creek from the highway by walking 1 km along foot paths while others use small boats to reach the creek from the campsite when ice conditions on Great Slave Lake permit access. Up to 1977 overnight angling trips were common but since then black bears have discouraged campers. While road and weather conditions are generally good in the spring, adverse weather may make the road impassable, thereby reducing angler-effort and consequently the catch in some years (particularly 1975).

Walleye in and adjacent to the North Arm of Great Slave Lake are also subject to commercial and subsistence exploitation. In Area IV of Great Slave Lake (Fig. 1) commercial production of walleye has averaged 1,700 kg. (round weight) and has ranged from 195 kg in 1974 to 2,529 kg in 1978. It is known that walleye are taken in high numbers by commercial gillnets (133-140 mm, stretched measure) off Spruce Point and Wrigley Point during August and September. Subsistence fishing occurs during the summer in the North Arm of Great Slave Lake, Frank Channel and in Marion Lake by the residents of Rae. The catch of walleye by this fishery is unknown but it is understood to be minimal since effort is low and lake whitefish is the preferred fish species.

MATERIALS AND METHODS

Study of the spring fish migrations in Mosquito Creek was initiated in May 1973 and various collection methods have been used from 1973 to 1978. A creel census was conducted each year to determine total angler-effort and angler-harvest by species. During 1974 and 1975 counting fences (weirs) were installed to enumerate migrant fish and determine their instream movement patterns. Additional capture methods such as gillnet, fyke net and hoop net have been used since 1976 to obtain fish for tagging and biological sampling. Biological information has also been collected on fish populations in the North Arm of Great Slave Lake by gillnet in 1976 and 1977. Following is a brief explanation of the equipment and procedures employed in each segment of the investigation. A more complete description is provided by Falk et al. (1980).

FIELD

Partial creel census operations were conducted in 1973 and 1974. The census was expanded during the next four years to gather more complete information on angler-effort, catch by day and catch by season utilizing creel census techniques and standard forms adapted from Falk et al. (1973, 1974a).

During 1974 and 1975 counting fences were installed in the center zone of Mosquito Creek approximately 0.5 km upstream from the mouth (Fig. 2). In 1974 the fence was a single trap operation designed to enumerate upstream migrants only. The structure was completed on 19 May and was operated until 23 May when a sudden downstream movement of fish forced the removal of the fence. The trap was operated on an irregular basis conforming to the number of fish entering the trap. In the following year a two-way fence was installed at the same location to enumerate both the upstream and downstream movements of fish. Initial fence construction was completed on 12 May but increasing water levels and resultant washouts prompted relocation of the structure 200 m upstream. The second fish fence was completed on 16 May prior to the removal of the original fence to permit continuous monitoring of the spawning/feeding migrations until operations ceased on 12 June.

Hoop and fyke nets were set in Mosquito Creek during 1978 to obtain fish for tagging and additional biological sampling. The fyke net was in operation from 19 May to 25 May in the mouth of Mosquito Creek. The net was constructed of 25 mm nylon mesh with a main lead of 80 m. The hoop net was positioned 0.5 km upstream and was monitored from 20 May to 27 May. It had a 20 m lead and a hoop diameter of 1.7 m. Neither trap completely blocked the stream and fish enumeration was not attempted during sampling and tagging operation. During periods of peak movement trap leads were lifted to allow passage of fish up the creek. The majority of fish captured were examined, tagged and released while a small portion was sacrificed and sampled for later biological analysis.

During June 1975 gillnets were set off the mouth of Mosquito Creek and from June to August, 1976 and 1977 gillnets were set between Waite Island and Frank Channel (Fig. 1). Gillnet gangs consisted of 50 m panels of 38, 64, 89, 114 and 140 mm (stretched measure) meshes.

Water temperatures were taken two to four times daily during sampling periods from 1974 to 1978 and chemical characteristics were recorded during the 1975 fish fence operation. A guaging staff was located 5 m below the fish fence and readings were taken at each trap check.

Walleye collected by angling, fish fence, hoop net, fyke net and gillnet from 1973 to 1978 were tagged. Numbered fluorescent orange Floy tags were applied using a Dennison tagging gun (model FDM-68). Tags were inserted into the left side of the fish near the base of the first dorsal fin and anchored through the posterior pterigiophores. Both the tags and tagging gun were held in mild disinfectant solution and rinsed in fresh water prior to each tag insertion. All angled fish were released immediately after tagging while those tagged from traps in 1975 and 1978 were held in enclosures for observation.

A portion of the total catch from each collection method was dead sampled by species for later biological analysis. Fork length (±1 mm) and weight (±25 g) were recorded. The incidence of external blemishes was recorded from 1976 to 1978. Scales were removed from below the lateral line and forward of the dorsal fin for later age determination. In 1978 samples of pelvic fin rays and dorsal spines were also taken as comparative aging structures. Sex and stage of maturity were determined by examination of the gonads and coded according to the maturity scale adapted from Falk et al. (1974b).

In 1975 ovaries were removed from 15 ripe female walleye taken from the upstream trap. The weight of each ovary (±5 g) was recorded prior to wrapping in cheesecloth and preservation in Gilson's fluid for later fecundity determination.

LABORATORY

Scales collected from walleye were cleaned, placed between two glass slides and the annuli from the image (x60) produced by an Eberbach microprojector. Ages were also determined from cross sections pelvic fin rays and dorsal spines following the procedure described by Campbell and Babaluk (1979). Total fecundity was determined using the gravimetric method of estimation described by Healey and Nicol (1975).

Total annual mortality rates (natural + fishing mortality) were calculated using the methods outlined by Robson and Chapman (1961). The total annual mortality rate is defined as the number of fish which will die during the year, divided by the initial number (Ricker 1958). Tests of significance were made at P=0.05 using the procedures outlined by Snedecor and Cochran (1968) for analysis of covariance, Student t-test, Chi square, analysis of variance and correlation coefficient.

RESULTS AND DISCUSSION

In this section a synthesis of investigation carried out from 1973 to 1978 on walleye from Mosquito Creek and vicinity is presented and discussed. Data on walleye and other fish species collected during the study are provided in tabular form in a separate report (Falk et al. 1980).

CREEL CENSUS

The fishing season for walleye on Mosquito Creek extended from as early as 6 May in 1976 to as late as 7 June in 1975. The average length of the season was 20 days (range = 16-27 days). Creel census periods ranged from 7 to 32 days (mean = 18 days) and accounted for an average of 86 percent of the fishing season (range = 39-100%).

The number of anglers frequenting Mosquito Creek over the spring fishing season increased from 105 in 1973 to a high of 295 in 1977, then decreased to 269 in 1978. Similarly, the number of angler-hours increased from 1973 to 1976 then decreased dramatically to 1978 (Fig. 3). Despite this decrease in effort (1976-78) the catch per angler remained relatively constant. Annual increases in the number of anglers averaged 32 percent (range = 0-66%) with the greatest increase from 1973 to 1976.

The total number of walleye caught by angling from Mosquito Creek ranged from a low of 282 in 1975 to a high of 567 in 1973 (mean = 410). There appeared to be no relationship/correlation between total catch and either the number of anglers or the hours fished as well as between total catch and year (1973 to 1978). Total catch appears to be more dependent upon the availability of walleye (strength of the spawning run) and weather than angler-effort.

Catches of walleye per angler-day and angler-hour (Fig. 3) decreased from 1973 to 1974, then remained relatively constant from 1975 to 1978. The average catch of walleye was 1.7 per angler-day (range = 1.3-5.4) and 0.6 per angler-hour (range = 0.5-2.3). These figures are somewhat lower than those of 1.11 and 1.29 walleye per angler-hour reported by Falk and Dahlke (1975) and Bond et al. (1978), respectively for the Hay River on the south shore of Great Slave Lake. Colby et al. (1979) reported that a good fishery exists when walleye are caught at a rate of 0.3 walleye per hour fished for all species. Walleye retained per angler-day ranged from a high of 5.1 in 1973 to a low of 1.3 in 1977 and 1978 (mean = 1.7). Angler success fluctuated somewhat from year-to-year (Fig. 3) and was the lowest (62%) in 1978; primarily due to the later than usual arrival of walleye in Mosquito Creek.

Afternoons and evenings were the times of day preferred by most anglers. From observations, peak angler activity occurred in the afternoon from 1500 to 1700 hr. After 1800 hr angling pressure increased again and by 2200 hr most people ceased fishing for the night. Angler-success, in terms of catch per hour, tended to be greater during these peak periods of angler-activity. Angler-success, in terms of catch per

angler-day, was variable over the fishing season with no consistent pattern from year-to-year. However, it was apparent that each year anglers generally enjoyed the greatest success in the last week of May, during the post-spawning period.

Walleye comprised 72 percent of the fish caught and were the preferred species with 96 percent of walleye retained by anglers. Northern pike, longnose suckers and the occasional round whitefish were also caught but together only made up 11 percent of the retained catch.

SIZE COMPOSITION

Walleye caught by all methods (angling, fish fence, trap nets) from Mosquito Creek (1973-78) had a mean length of 431 mm (N = 1738; range = 286-600 mm). Males had a mean length of 422 mm (N = 1362; range = 286-600 mm) while females had a mean length of 464 mm (N = 376; range=251-572 mm). The average lengths of walleye from Mosquito Creek and vicinity are summarized below by capture method and by sex:

Capture Method	Year(s)	Sex	N	Mean Length (mm)	Modal Length Group(mm)
Angling	1973-78	M	511	414	410 - 419
		F	55	458	480 - 489
Fish Fence	1974-75	M	326	408	390 - 399
		F	225	461	450 - 459
Gillnet	1976-77	M	179	392	370 - 379
		F	89	428	410 - 419
Hoop and Fyke Nets	1978	M	524	439	430 - 439
		F	96	490	500 - 509

Length-frequency distributions for walleye caught by all methods are shown in Fig. 4. Each means of capture produced a different size composition. The distribution for walleye caught by angling is skewed to the left revealing that this capture method is selective to smaller fish and to males. The fish fence sample shows a size distribution that is skewed to the right which, in part, is attributed to the presence of larger females. Walleye caught by hoop and fyke nets in Mosquito Creek conformed to a more normal distribution. However, since the traps were not fished throughout the spawning migration this means of capture is not directly comparable to those of angling and fish fence. The distribution for walleye caught by gillnets in the North Arm of Great Slave Lake is bimodal as the sample was composed of both smaller and immature fish.

Differences in selection for size of walleye by various types of gear have been reported by Forney (1961) and Elsey and Thompson (1977). They found that angling was selective to smaller individuals and continuous trap netting during spawning migrations was most representative of the spawning population. Colby et al. (1979) mentioned that most collection gear has a tendency to bias samples toward the larger members of the population. He also noted that the size composition of adults on the spawning grounds appears to be different from that on the lake at other times of the year.

Length-frequency distributions of walleye caught by angling are shown by year in Fig. 5. There is an apparent shift toward smaller fish from 1973 to 1978. While not a consistent decrease, 63 percent of walleye from 1973 are greater than 400 mm and from 1978 this proportion is 42 percent. However, this may be attributed to year-to-year fluctuations in year class strength and characteristics of the spawning population. Length-frequency distributions of walleye caught by fish fence in 1974 (upstream) and in 1975 (upstream and downstream) are shown in Fig. 6. Size compositions of the upstream samples from 1974 and 1975 appear the same indicating similar size characteristics of the spawning populations in both years. Distributions for the upstream and downstream samples from 1975 appear different because the early portion of the upstream run, which was comprised mainly of males, was missed. The size composition of walleye in the spawning runs were similar to those reported by Colby et al. (1979). The majority of males from Mosquito Creek were from 360 to 480 mm and the majority of females were from 420 to 500 mm.

AGE DETERMINATION

Rawson (1957) noted that the exact age of walleye older than 13 was difficult to determine using scales and Olson (1958) reported difficulties starting at age 5. Further, Carlander (1961) encountered a more than average difficulty in interpretation for this species. He found that the ages secured in two readings did not agree for 31 percent of the fish but 80 percent were within a year of each other. Carlander (1961) concluded that ages of individual walleye cannot be assessed with a great deal of certainty, but the errors average out or are submerged to the degree that bias does not interfere with general interpretations when samples are large.

In the present study ages determined by scales and dorsal spines/fin rays were compared for a sample of 82 walleye collected from Mosquito Creek in 1978 (Fig. 10). Twenty-nine percent agreement was found for a sample of 70 where both scale and dorsal spine/pelvic ray ages could be determined. Forty-nine and 13 percent of the ages assigned differed by one and two years, respectively. Agreement of scale age = dorsal spine/fin ray age appears good until age 10 but by age 16 the scale age is considerably lower than that determined by dorsal spine/fin rays (Fig. 10a). This causes the age-frequency distribution for the scale method to be truncated (Fig. 10b) and may result in a higher annual mortality rate. However, growth curves for length are similar to age 18 when an asymptote is reached for walleye aged by dorsal spines/fin rays (Fig.10c). Similar observations have been made by Dubois and Lagneaux (1968) who compared ages determined by scales and otoliths for lake trout.

From this analysis it is concluded that the scale method provides information which is adequate for the purpose of the present study with certain limitations. While the scale method may be considered to be unreliable for

walleye 14 yr and older, only 12 percent of the total 1973-78 sample was in this category.

AGE COMPOSITION

Walleye caught by all methods from Mosquito Creek had a mean age of 11.0 yr (N = 1388; range = 6 - 19). Males had a mean age of 10.5 yr (N = 850; range = 6-18) while females had a mean age of 12.4 yr (N = 276; range = 7-17). Average ages of walleye from Mosquito Creek and vicinity are summarized below by capture method and by sex:

Capture Method	Year(s)	Sex	N	Mean Age (yr)	Modal Age (yr)
Angling	1973-78	M	488	10.0	9
		F	49	11.3	10
Fish Fence	1974-75	M	301	11.0	9
		F	211	12.6	12
Gillnet	1976-77	M	174	7.2	8
		F	76	9.4	9
Hoop and Fyke Net	1978	M	61	11.4	11
		F	16	13.1	16

Age-frequency distributions for walleye caught by all methods are shown in Fig. 7. As demonstrated by the length-frequency distributions each means of capture produced different age-frequency distributions: angling - skewed to the left; trap (fish fence) - skewed to the right; gillnet - bimodal; and hoop and fyke nets - normal. As a result of this comparison and that presented under size composition, pooling samples taken by the various means of capture to obtain representative size and age compositions was not attempted.

Age-frequency distributions for walleye caught by angling are shown by year in Fig. 8. There appears to be a shift towards younger walleye from 1973 to 1978. Like the change in length-frequency distributions this decrease is not consistent but 55 percent of walleye from 1973 and 46 percent of walleye from 1978 are greater than age 10. Year-to-year variations in mean age and the apparent shift to younger walleye from 1973 to 1978 may be the result of variations in year class strength and characteristics of the spawning population as noted by Rawson (1957). Age-frequency distributions for walleye caught by fish fence in 1974 (upstream) and in 1975 (upstream and downstream) are shown in Fig. 9. While this means of capture is considered by Forney (1961) to sample age groups in proportion to their abundance it should be noted that a portion of the males was missed from the upstream run in both 1974 and 1975.

Colby et al. (1979) discussed the age composition of walleye from North America. They found that age groups 3 and 4 constitute the majority of the adult population vulnerable to sampling gear in most lakes and that the numbers in age groups greater than age 4 generally tend to decrease with each subsequent age group. Age groups 12 and 13 were modal for Mosquito Creek walleye. Forney (1961) found that the age composition of walleye caught by trap nets during spawning runs did not differ significantly from samples obtained from the open lake during other times of the year by various methods. However, distinctively different age compositions were found by trapnetting in Mosquito Creek and by gillnetting in the North Arm of Great Slave Lake (Fig. 1).

The average life-expectancy of walleye is reported by Colby et al. (1979) to vary with latitude, from about 12 to 15 yr in the northern limits of its range to 5 to 7 yr near the extreme southern limits. Scott and Crossman (1973) reported the maximum age for walleye to be 20 yr but Schneider et al. (1977) estimated ages of walleye up to 26 yr from Lake Gogebic, Michigan based upon tag returns. Walleye from Mosquito Creek were aged up to 19+ yr by scales and up to 24+ yr by dorsal spines. As reported elsewhere and summarized by Colby et al. (1979) female walleye live longer than males.

GROWTH

Curves illustrating growth in length and weight are illustrated in Fig. 11. Data from the various means of capture were combined to illustrate growth in length and weight since there were no apparent differences in growth among years, means of capture and sampling locations. Growth in length and weight for male and female walleye appear the same to age 8. Past this age females tended to be longer and heavier than males at each successive age and also appeared to live longer than males. Differences in growth rate between male and female walleye have been reported elsewhere with evidence of divergent growth occurring as early as age 1 and 2 (Colby et al. 1979).

The difference in growth between male and female walleye from Mosquite Creek was compared by analysis of covariance from the following semi-logarithmic relationships:

Male:

$\log_{10}\text{Len} = 2.4629 + 0.015\ (\text{Age});\ N = 769;\ s_b = 0.001$

$\log_{10}\text{Wt} = 2.3995 + 0.050\ (\text{Age});\ N = 769;\ s_b = 0.002$

Female:

$\log_{10}\text{Len} = 2.4696 + 0.017\ (\text{Age});\ N = 230;\ s_b = 0.001$

$\log_{10}\text{Wt} = 2.4062 + 0.058\ (\text{Age});\ N = 230;\ s_b = 0.003$

The difference in slope ($F = 2.4$; $df = 1,995$) between the length-age relationships was not significant ($P > 0.05$) while the difference between adjusted means ($F = 116.5$; $df = 1.996$) was signigicant at $P = 0.01$.

From tag return information it was possible to compare observed and expected increments by age. Observed length increments were determined from lengths recorded at tagging and recapture while expected values were determined from a smooth curve as shown in Fig. 11. Correspondence between observed and expected length increments

after one year appeared close but they were significantly different ($t = 16.59$; $df = 46$; $P < 0.01$). This analysis suggests that tagging has some effect on growth rate. However, difference may be attributed to the assumption of average length increments based on a smooth growth curve.

Growth curves for walleye from Mosquito Creek and vicinity are compared to those from selected North American sources in Fig. 12. It is evident from this illustration that growth of walleye from Mosquito Creek ranks among the lowest from North America and approximates walleye growth rates from other waters in the Northwest Territories. Colby et al. (1979) provide a similar comparison of walleye growth rates from North America and demonstrate a cline of decreasing growth rate from south to north.

MORTALITY

Catch curves for walleye caught by angling from Mosquito Creek are illustrated by year in Fig. 13. Total annual mortality rates for angled walleye ranged from a high of 71 percent in 1974 to a low of 38 percent in 1978 and revealed a general decrease from 1973 to 1978. Catch curves for walleye caught by the various means of capture are presented in Fig. 14. Annual mortality rates by capture method and by sex are summarized below:

Capture Method	Sex	N	Mortality Rate (A)	Age Classes
Angling	M	266	44	10 - 17
	F	41	35	10 - 14
	All Fish	341	42	10 - 17
Fish Fence	M	127	56	12 - 16
	F	160	46	12 - 17
	All Fish	403	50	12 - 17
Gillnet	M	67	55	9 - 13
	F	57	50	9 - 13
	All Fish	126	53	9 - 13

For all means of capture the annual mortality rate of male walleye was higher than that of females. Sexual divergence in mortality rates with increasing age has been reported for walleye but it may result from the interaction of size-selective exploitation and the sexual growth differential.

Mortality rates for walleye from various waters are summarized by Colby et al. (1979). He lists total annual mortality rates ranging from 13 percent to 84 percent with common rates ranging between 40 and 55 percent. While this is the range of mortality determined for Mosquito Creek walleye it is expected that actual mortality rates are lower due to the scale method which tends to underestimate the age of walleye above age 10 and particularly past age 14.

SEX RATIO AND MATURITY

Sex ratios varied greatly among the means of capture, further emphasizing the difficulty in obtaining representative information on the walleye population from Mosquito Creek for the present study. A summary of the sex ratio by capture method is provided below:

Capture Method	Year(s)	N	F/M Ratio	χ^2
Angling	1973-78	567	0.11	368.34*[a]
Fish Fence				
Upstream	1974	170	1.07	0.68[NS b]
Upstream	1975	130	1.60	6.92*
Downstream	1975	251	0.29	74.78*
Gillnet	1976-77	268	0.50	30.22
Hoop and Fyke Nets	1978	620	0.18	295.50*

[a]Significant at P=0.05; [b]Not significant

Angling was most selective towards males and this may be attributed to their pre- and post-spawning behavior (i.e. preceding the arrival of females on the spawning grounds and remaining there longer) as well as the tendency of females to avoid angling gear. The sex ratio among walleyes during spawning runs and on the spawning grounds usually favors males which mature earlier with individual observations ranging from 51 to 99 percent males (Colby et al. 1979). While the sex ratio for the fish fence sample from 1975 (upstream and downstream combined) favored males by 1.5:1 this ratio is low since unknown numbers of males were missed from the early part of the upstream run and the late part of the downstream run.

Sex ratios were found to increase in favor of females with increasing size and age. This has been reported for other walleye population in North America by Colby et al. (1979) who attributed this to the faster growth rate and greater longevity for females.

All walleye caught by angling from Mosquito Creek were considered to be sexually mature. Ages of the youngest mature male and female were 6 and 8 respectively. Full sexual maturity was reached at age 9 for males and at age 10 for females. For the fish fence sample (1974-75) the youngest mature male was age 7 and the youngest mature female was age 9 with full sexual maturity at ages 9 and 12, respectively.

The earlier maturity of males has been noted elsewhere (Scott and Crossman 1973; Colby et al. 1979). Colby et al. (1979) reported a wide range in the age of sexual maturity (1-8) with late maturity usually associated with colder waters where there is a tendency for late maturing walleye to live longer than those which mature earlier. While Deason (1933) and Carlander (1945) have reported that some older walleye may be sterile or fail to spawn annually there was no evidence of this for walleye from Mosquito Creek.

FECUNDITY

In 1975, ovaries were taken from 15 walleye ranging in length from 449 to 533 mm. The

estimated total number of eggs per female ranged from 25,300 to 86,660 with an average of 63,863 eggs per female. Actual counts differed from the estimated values by 13 and 11 percent for right and left ovaries, respectively. There were no significant correlations, ($P > 0.05$) between fecundity and either length ($r = 0.14$) or weight ($r = 0.30$).

Average fecundity for Mosquito Creek walleye was 45,037 eggs·kg^{-1}. This figure is somewhat lower than average for those reported for southern walleye populations by Colby et al. (1979) who present information on egg production ranging from 29,700 to 82,700 eggs·kg^{-1}.

SPAWNING MIGRATION

Upstream migration

Walleye spawning migrations into streams appears to be initiated by increasing water temperatures and often begins under the ice before breakup in the spawning stream (Niemuth et al. 1962; Hokanson 1977; Collette et al. 1977). Spawning normally begins shortly after ice breakup at water temperatures of 6.7-8.9°C but has been known to take place over a range of 5.6-11.1°C (Scott and Crossman 1973). The actual spawning temperature also appears to be a function of the thermal history and maturation state of the stock (Rawson 1957). He found that the main run into streams on Lac la Ronge, Saskatchewan, usually took place between 4.4 and 5.0°C. While some spawning took place at these temperatures spawning activity was greatest between 7.7 and 10°C.

The temporal pattern of the 1975 upstream migration of walleye into Mosquito Creek is shown in Fig. 15. At the time of initial fish fence installation on 12 May the mean water temperature was 4.4°C and it was obvious that the spawning migration was underway. When the fence was relocated on 16 May the mean water temperature was 3.7°C and 6 walleye were counted through the upstream trap on 17 May. The peak upstream movement occurred on 20 May when the water temperature first exceeded 10°C. While walleye continued to move upstream until early June, 96 percent of the migration had passed the fence by 24 May. A total of 2270 walleye were counted through the fence from 17 May to 12 June. It was apparent that a significant portion of the upstream migrants were missed from the early part of the run but it was clear that males arrived first at the spawning grounds and outnumbered females during the initiation of the spawning migration. However, females outnumbered males by 4:1 during the peak upstream movement (19-21 May) and comprised the greatest percentage of the dead sample. While traps were checked at intervals according to the strength of the run the upstream movement of walleye took place mainly during the nighttime as 66 percent of the migrants were passed through the fence between 2200 and 0600 h. The pre-spawning behavior of walleye including early movement of males into spawning streams, the greater proportion of males in spawning runs and diel movements has been reported previously and is summarized for various North American sources by Colby et al. (1979).

In 1974, 2,678 walleye were counted through an upstream trap. This count was partial because on 23 May the fence was lowered to permit the downstream movement of walleye, when a rapid drop in temperature occurred.

Downstream migration

The temporal pattern of the downstream movement of walleye is shown in Fig. 15. Three peaks of movement were enumerated through the downstream trap. The first peak occurred shortly after trap installation and preceded the upstream peak by one day. The second and third peaks occurred 5 and 11 days later and they appeared to be associated with rapidly decreasing water levels. Males outnumbered females during each of the three peaks and dominated females for the overall downstream dead sample. Females only outnumbered males for four days after the initial downstream peak.

Spawning period

In 1975 the spawning period for walleye in Mosquito Creek appeared to last about eight days. All males observed on 17 May were in ripe condition while females were not fully ripe until 21 May. The first walleye (both sexes) that were determined to be spent were passed through the downstream trap on 18 May. All males examined were in spent condition after 26 May and all females were spent after 3 June. During the 1975 fish fence operation 65 and 332 walleye were tagged in the upstream and downstream traps, respectively. Thirty of the walleye tagged in the upstream trap were recaptured in the downstream trap, having spent an average of 5.6 days upstream (range = 1-16 days). The mean number of days spent upstream for males was 7.0 (range = 1-13 days) while that for females was 2.9 (range = 1-8 days). Colby et al. (1979) reported that the length of the walleye spawning season ranges from 4 to 28 days with peak periods of spawning activity ranges from 1 to 12 days. Ellis and Giles (1965) suggested that females can complete spawning in one night whereas males have the potential for spawning over a longer period. Priegel (1970) provided further evidence of this in that non-ripe female walleye would ripen, spawn and leave the spawning grounds within one day.

Mean weight loss during the spawning period for tagged walleye was found to be 164 g for females (N = 20; range = 50-250 g) and 96 g for males (N = 15, range = 70-170 g). Weight loss is attributed, in part, to the loss of gonadal products. From information gathered for fecundity estimates the average wet weight of mature/ripe ovaries sampled from walleye in the upstream trap was determined to be 125 g (N = 15; range = 55-180 g). The weight loss for females was not significantly different from that of wet ovary weight ($t = 1.006$; $df = 33$; $p > 0.05$).

Trap records from 1975 provide evidence that limited movement occurred on a daily basis

within Mosquito Creek. Only seven of 332 walleye that were tagged in the downstream trap were recaptured in the upstream trap. Eschemeyer (1950) and Ellis and Giles (1965) observed that walleye often departed from the spawning grounds during the day and may completely leave the stream. Since movement of this nature were confined to a four day period early in the spawning run and only three percent of tagged fish were recaptured it is evident that the majority of spawners remained upstream during the spawning period in 1975.

Observations were made on the movements and activity patterns of walleye in Mosquito Creek during the spawning period in 1975. During daylight hours walleye were observed in depressions along the length of the creek. Fish were inactive and only moved short distances when disturbed. Walleye were most active in the evening and at night with large numbers moving on to gravel bars in shallow water. Courtship behavior as summarized by Colby et al. (1979) was observed on many occasions at night. Four or five tightly grouped walleye would rise rapidly to the surface, break water violently and then return to the bottom. Although no gonadal products were observed the intensity and frequency of these actions would suggest that spawning had occurred. Activity of this nature was frequent for two to three days after water temperatures reached 7 to 8°C then declined abruptly as walleye completed spawning and left the creek. A number of smaller walleye, mostly males, were observed to remain in the upper reaches of the creek for one to two weeks after spawning ceased.

Environmental variables

Water temperature has been observed to have various affects upon the upstream and instream movements of walleye. Derback (1974) and Regier et al. (1969) reported that a drop in water temperature caused potential spawners to move off the spawning grounds. Also, Stoudt (1939), Rawson (1957) and Johnson (1971) noted prolonged runs in cooler years and concentrated runs in years when water temperature rose considerably. During 1975, water temperatures varied little over a 24-hour period and increased at a relatively constant rate over the spawning period. Upstream movement of walleye was consequently quite predictable. However, during 1974 a heavy snowfall caused water temperatures to drop from 8.8°C to 3.3°C over a 48-hour period. As a result large numbers of walleye moved downstream and congregated in front of the fish fence necessitating lowering of the structure. Only a few walleye returned to the creek even after water temperatures reached previous levels.

During 1977 and 1978 heavy rains fell during the spawning period and although temperatures declined slightly, the water became turbid and walleye were observed to move out of the stream and to hold in deep pools beyond the mouth of the creek. In both years walleye moved back into Mosquito Creek when the water cleared. In 1978, R. Moshenko (pers. comm.) observed that walleye in Mosquito Creek dropped back toward the lake during the night when the water temperature decreased and returned in the morning. During the night they were seen to build up against the wing of a hoop net but moved upstream in the morning as the water temperature rose.

While the peak spawning migration into Mosquito Creek in 1975 occurred when the water temperature first exceeded 10°C, upstream movements and spawning activity occurred at lower temperatures from 1976 and 1978. Movements into Mosquito Creek were observed at 5.2°C in 1976, 4.6 C in 1977 and 4.5°C in 1978. Spawning activity was observed at 8.2, 6.4 and 7.4°C for 1976, 1977 and 1978, respectively.

Population estimate

The upstream count of walleye entering Mosquito Creek in 1974 was 2,678 before fence operations were terminated. In 1975 the upstream and downstream counts of walleye were 2,270 and 5,430, respectively. As previously mentioned a considerable portion of the upstream migration was missed rendering this count useless. Consequently, the downstream count of 5,430 must be used as the basis for estimating the spawning population of walleye in Mosquito Creek for 1975. Since it was apparent from tagging information that three percent of the upstream count during the first four days of fence operation moved downstream then upstream again, the count was corrected to 5,382. This figure was further revised to 5,607 by including the retained catch of walleye taken above the fish fence in 1975. The population estimate for walleye in 1975 of 5,600 is considered to be minimum since a few walleye were still observed in the creek after fish fence operations were abandoned.

The 1975 spawning population estimate of walleye is considered to be typical for Mosquito Creek in years of favorable environmental conditions. However, as observed in other years for Mosquito Creek (e.g. 1974) and as reported elsewhere (Rawson 1957; Johnson 1971), substantial year-to-year variations in the size of the spawning population is known to occur.

POST-SPAWNING MOVEMENTS

Tag returns

From 1975 to 1978, 1178 walleye were tagged in Mosquito Creek and during this period, 114 were recaptured. A summary of the tag returns from Mosquito Creek and other locations is presented below.

		Tags Returned			
		Mosquito Creek		Other Locations	
Year	No. Tagged	No.	(%)	No.	(%)
1973	68	8	(5.9)	4	(2.1)
1974	150	16	(10.6)	14	(9.4)
1975	303	28	(9.2)	7	(2.3)
1978	657	0	-	37	(5.6)
Total	1178	52	(4.4)	62	(5.3)

The 114 recaptures were from on-site operations (40%), angling in Mosquito Creek (7%), subsistence and commercial netting in the North Arm of Great Slave Lake (38%) and subsistence netting in Frank Channel and Marion Lake (15%).

Locations of recaptures and distances travelled relative to Mosquito Creek are shown in Fig. 16. For 62 walleye recaptured from locations other than Mosquito Creek the mean distance travelled by water was 69 km (range = 23-237 km). Colby et al. (1979) summarized the North American literature with respect to distances travelled by walleye and reported that in most waters the majority of spawners migrate less than 16 km from the spawning grounds and even in some large water bodies such as Lake Superior a large proportion of mature fish move no more than 5 km from their spawning grounds. They also report that it is not uncommon for some individuals to be recaptured at much greater distances from their point of release. For example, 21 percent of the adults tagged in Lake Winnebago, Wisconsin, were recovered from 40 to 156 km from their point of release (Priegel 1968). Maximum distances travelled for Mosquito Creek walleye are not excessive when compared to 211 km (Carbine and Applegate 1946), 282 km (Ferguson and Derksen 1971) and 380 km (Wolfert 1963).

It is important to note for the purpose of interpretation of tag return information that, apart from the spawning period in Mosquito Creek, walleye are only subject to capture as follows: summer subsistence fisheries of Marion Lake, Ptarmigan Point, Wool Bay and Yellowknife Bay; the summer/fall commercial fishing in the North Arm of Great Slave Lake (Area IV); and angling during the spring and summer in Frank Channel and the Yellowknife River (Fig. 16).

Dispersal

Recaptures of tagged walleye indicated that movement occurred both north through Frank Channel into Marion Lake and south into the North Arm of Great Slave Lake (Fig. 16). It was apparent from unsuccessful gillnetting attempts for walleye off the mouth of Mosquito Creek during July and August from 1976 to 1978 and in 1975 immediately after breakup, that the post-spawning dispersal of walleye is rapid and complete. Also five tagged walleye were caught in the Frank Channel-Marion Lake area within one week after spawning ceased in 1976. Two of these returns indicated that walleye had travelled 8 to 10 km under the ice in the North Arm of Great Slave Lake before entering the Frank Channel. The total distance travelled for these five walleye averaged 21 km (range = 16-27 km), or a daily distance of 3 km. Similar patterns of post-spawning dispersal have been presented by Colby et al. (1979). They found that in number of areas walleye have been observed to disperse throughout the available habitat shortly after spawning and the rate of migration of individuals has rarely been reported to be greater than 3 km/day.

Multiple tag return information provided evidence that the post-spawning dispersal and movement to summer feeding areas could occur in close aggregations or discrete schools. Three walleye bearing successive tag numbers were released in Mosquito Creek on 15 May 1978 and were recaptured from Ptarmigan Point in the same gillnet on 15 July 1978. Two other multiple tag returns on similar dates suggested that adult walleye migrated to and from summer feeding areas in discrete schools and maintained such associations during the summer. Similar findings have been mentioned by Colby et al. (1979) who, from a synopsis of the North American literature, report that adults are usually closely associated with respect to movement and schooling and that some closely associated populations remain spatially distinct throughout the year.

Summer distribution

Tag returns from subsistence and commercial netting indicated that Mosquito Creek walleye may migrate to several distinct summer feeding areas in the North Arm of Great Slave Lake and in Marion Lake. Also, it is suggested that walleye appear to utilize the same summer feeding areas in successive years. Walleye were caught in gillnets from late June to early July and remained in the same general area throughout the summer/fall fishing season with the greatest commercial catch occurring in August and September. Areas supporting steady catches of walleye during the summer were McIver Bay, Sulphur Point, Black Spruce Point and Ptarmigan Point (Fig 1). Most of the walleye catch was taken at depths of 10 to 20 m in near shore areas. These observations are supported by Olson et al. (1978) who summarized the work of Schupp (1972) and Forney (1963) by stating that "Though some adult walleyes range great distances to and from spawning areas, movement following post-spawning migrations does not appear extensive and some walleyes appear to select the same general area for feeding in successive years".

Homing behavior

The tendency of walleye to return to the same spawning area in successive years (homing behavior) has been well documented and summarized recently by Colby et al. (1979). Olson et al (1978) state that homing is probably an adult-learned behavior influenced by physical characteristics of the environmental repeated migrations. Both tag returns and observations of tagged fish provide evidence that walleye return have the ability to spawn in Mosquito Creek in successive years. Recapture information relative to the year of tagging in Mosquito Creek is summarized below.

Year Tagged	No. Tags Returned	Years to Recapture 1	2	3	4	5	No. Ripe
1973	11	-	8	-	-	3	11
1974	16	15	-	-	1	-	15
1975	22	5	5	12	-	-	21
Total	49	20	13	12	1	3	47

It is apparent from the above summary and analysis of biological information that walleye have

the capability to spawn each year once sexual maturity is reached. This ability may be subject to environmental conditions such as open water period or mean summer water temperature.

During May 1977 an aerial reconnaissance was carried out on the west shore of the North Arm of Great Slave Lake to assess the spawning potential of streams in this area for walleye. Seven streams were evaluated, of which only Mosquito Creek and the Dufort River (Fig. 1) were observed to possess suitable spawning habitat for walleye. A ground survey conducted on the Dufort River during the same month confirmed that walleye spawn in this stream and revealed the presence of several tagged walleye from Mosquito Creek. One of these fish was recaptured and was found to be tagged in Mosquito Creek in 1975. It is therefore evident that while most walleye return to Mosquito Creek to spawn, both streams and possibly others may be used. Weaknesses in homing instinct of walleye have been shown by Smith et al. (1952) and Cross (1964) who suggested that walleye may choose the closest available stream, especially when spawning sites exist in close proximity. While there are insufficient data from the present study to formulate firm conclusions regarding the homing of walleye to spawning streams, the physiographic division between Marion Lake and the North Arm of Great Slave Lake may modify movement patterns as suggested by Olson et al. (1978). Walleye may move to the spawning stream closest to their summer feeding area and/or become associated with different aggregations over the summer or winter or during spawning migrations.

IMPLICATIONS FOR MANAGEMENT

Results of the six-year investigation on Mosquito Creek indicate that angling at the present level of exploitation is having a minimal effect on the spring spawning population of walleye. Angler-pressure increased from 1973 to 1976 and has remained relatively stable from 1976 to 1978. Angler-success in terms of the numbers of walleye caught per angler-day and per angler-hour has been constant from 1974 to 1978. The size and age composition of the retained catch of walleye, while appearing to have declined somewhat from 1973 to 1978, has not changed appreciably. Year-to-year variations in size and age of the retained catch and the apparent decrease may be attributed to characteristics of the spawning population, year-class strength and commercial fishing rather than angling.

Angling was found to be selective to male walleye with males comprising 90 percent of the angled catch from 1973 to 1978. This is a result of females being vulnerable to angling for a shorter period than males and the apparent non-feeding behavior of females while on the spawning grounds. Since it is known that male walleye may spawn with more than one female (Colby et al. 1979) the perpetuation of the spawning population of walleye in Mosquito Creek is assured at the present level of exploitation.

The number of walleye that utilize Mosquito Creek for spawning each spring is considered to be quite small in comparison to the total available walleye population in the North Arm of Great Slave Lake. Walleye may enter other streams to spawn (e.g. Dufort River) and may even spawn in the North Arm and in the Marion Lake area. Further, from commercial catches of walleye and test netting in Area IV it is evident that the exploitable walleye population is large enough to withstand increased fishing effort. Removal of less than 10 percent of the spawning population of walleye in Mosquito Creek each year is not regarded to be high in comparison to other ongoing fisheries with exploitation rates averaging between 20 and 30 percent (Colby et al. 1979). Mraz (1968) reported that annual catch rates (angling) of 19 to 24 percent did not cause an overharvest. Since exploitation rates for northern fish populations should generally be lower than those for southern populations, removal of 20 to 30 percent of the spawning population of walleye in Mosquito Creek may result in overexploitation.

Ongoing fishery management requirements for Mosquito Creek are limited to periodic monitoring of angler-effort and angler-success. Further biological investigation is only required if a dramatic increase in angler-pressure and harvest of walleye is demonstrated. In addition, the opportunity exists for expansion of the walleye sport fishery in the North Arm-Marion Lake areas.

RECOMMENDATIONS

1. Periodic monitoring should be carried out every two years on Mosquito Creek from 1979 to 1982 to obtain catch and effort information, to recover tagged fish and to assess angling quality.

2. While the spawning population of walleye utilizing Mosquito Creek does not appear to be in immediate danger of overexploitation, the sport fishery should be fully reassessed in 1982 to determine the need for a comprehensive creel census and biological sampling program. Elements of this program should include: enumeration of the spawning population of walleye; delineation and assessment of walleye spawning areas in and around the North Arm of Great Slave Lake; determination of post-spawning dispersal and summer feeding areas of walleye; and monitoring the subsistence and commercial fisheries of the North Arm of Great Slave Lake for walleye.

3. From examination of growth curves for walleye and comparison of ages determined by scales and dorsal spines/pelvic rays it was evident that the scale method underestimates the actual fish age, particularly walleye aged as 14 and older. Dorsal spines and pelvic fin ray samples should therefore be taken in addition to scales from walleye sampled in the Northwest Territories, especially for longer than 400 mm in length.

4. The present level of exploitation for walleye and other game fish species in the Marion Lake/North Arm area of Great Slave Lake by sport, commercial and subsistence fishing is low in comparison to anticipated potential levels. Consideration could therefore be paid to development of sport fishing opportunities in this region (e.g. Marion Lake, Frank Channel, Dufort River).

ACKNOWLEDGMENTS

In 1973 and 1974 field studies were designed and field work was carried out under the direction of S. Stephansson. S. Davies supervised field operations in 1975 and participated in data collection and analysis. R. Moshenko directed the program from 1976 to 1978. The authors appreciate the assistance given by summer staff: B. Corbett, D. Rudy, H. Hommel, R. Mulders, F. Hnytka, R. Sie, A. Mains and D. Declief. B. Wong with the Northwest Territorial Wildlife Service provided assistance and additional summer staff in 1976-77. D. Brackett, Environmental Protection Service, Yellowknife, provided field equipment and assisted in stream flow measurements and creel census operations. Thanks are extended to Fisheries and Oceans District Office, Yellowknife, for their cooperation and the assistance of Fishery Officers, D. Green and D. Desjardins. J. Babaluk and R. Erickson, Fisheries and Oceans, Winnipeg, determined the ages of walleye by dorsal spines and fin rays.

The authors thank D. Bodaly, S. Campbell, R. Moshenko and A. Kristofferson for their critical review of the manuscript.

REFERENCES

BOND, W.A. In prep. Summary of investigations of the fishery resources of the Athabasca River downstream of Fort McMurray, Alberta. Prepared for the Alberta Oil Sands Environmental Research Program by Department of Fisheries and Oceans.

BOND, W.A., R.W. MOSHENKO, and G. LOW. 1978. An investigation of walleye, *Stizostedion vitreum vitreum* (Mitchill), from the sport fishery of the Hay River, Northwest Territories, 1975. Can. Fish. Mar. Serv. MS Rep. 1449: v + 19 p.

CAMPBELL, J.S., and J.A. BABALUK. 1979. Age determination of walleye, *Stizostedion vitreum vitreum* (Mitchill), based on eight different structures. Can. Fish. Mar. Serv. Tech. Rep. 849: iv + 21 p.

CARBINE, W.F., and V.C. APPLEGATE. 1946. Recaptures of tagged walleye, *Stizostedion vitreum vitreum* (Mitchill), in Houghton Lake and the Muskegen River, Roscommon County, Michigan. Copeia 1946(2): 97-100.

CARLANDER, K.D. 1945. Age, growth, sexual maturity and populations of the yellow pike-perch, *Stizostedion vitreum vitreum* (Mitchill), with reference to the commercial fisheries, Lake of the Woods, Minnesota. Trans. Am. Fish. Soc. 73: 90-107.

1961. Variations on rereading walleye scales. Trans. Am Fish. Soc. 90(2): 230-231.

COLBY, P.J., R.E. McNICOL, and R.A. RYDER. 1979. Synopsis of biological data on walleye, *Stizostedion vitreum vitreum* (Mitchill 1818). FAO Fish. Synop. 119: 139 p.

COLLETTE, B.B., M.A. ALI, K.E.F. HOKANSON, M. SMIRNOV, J.E. THORPE, A.H. WEATHERBY, and J. WILLEMSEN. 1977. Biology of the percids. J. Fish. Res. Board Can. 34: 1090-1899.

CROSS, J.E. 1964. Walleye distribution and movements in Berlin Reservoir, Ohio. Ohio Dep. Nat. Resour. Div. Wildl. Publ. W-337: 9 p.

DEASON, H.J. 1933. Preliminary report on the growth rate, dominance and maturity of pike perches *Stizostedion* of Lake Erie. Trans. Am. Fish. Soc. 63: 348-360.

DERBACK, B. 1947. The adverse effects of cold weather upon the successful reproduction of pickerel, *Stizostedion vitreum*, at Heming Lake, Manitoba, in 1947. Can.Fish Cult. 2: 22-23.

DORAN, L.D. 1974. Environmental impact assessment of the portion of the Mackenzie Gas Pipeline from Alaska to Alberta, P-2 205-268. In Fish Research Reports, Vol. IV of Environmental Impact Assessment of the Portion of the Mackenzie Gas Pipeline from Alaska to Alberta. Environmental Protection Board, Winnipeg, Manitoba.

DUBOIS, A., and R. LAGNEAUX. 1968. Comparative study of the age as determined by scales and otoliths of the lake trout, *Salvelinus namaycush*, of Lake Mistassini, Quebec. (Transl. from French by Fish. Res. Board Can. Transl. Ser. No. 2883, 1974.)

ELLIS, D.V., and M.A. GILES. 1965. The spawning behavior of the walleye, *Stizostedion vitreum* (Mitchill). Trans. Am. Fish. Soc. 94(4): 358-362.

ELSEY, C.A., and R.T. THOMPSON. 1977. Exploitation of walleye, *Stizostedion vitreum vitreum*, in Lac des Mille Lac, Northern Ontario, by commercial and sport fisheries, 1958-75. J. Fish. Res. Board Can. 34: 1769-1773.

ESCHEMEYER, P.H. 1950. The life history of the walleye, *Stizostedion vitreum vitreum* (Mitchill), in Michigan. Mich. Dep. Conserv. Inst. Fish. Res. Bull. 3: 99 p.

FALK, M.R., and L.W. DAHLKE. 1975. Creel and biological data from streams along the south shore of Great Slave Lake, 1971-74. Can. Fish. Mar. Serv. Data Rep. CEN/D-75-8: 87 p.

FALK, M.R., D.V. GILLMAN, and L.W. DAHLKE. 1973. The 1972 sport fisheries on Great Bear and Great Slave lakes, Northwest Territories. Can. Fish. Mar. Serv. Tech. Rep. Ser. CEN/T-73-8: 100 p.

1974a. 1973 creel census data from sport fishing lodges on Great Bear and Great Slave lakes, Northwest Territories. Can. Fish. Mar. Serv. Tech. Rep. Ser. CEN/T-74-5: 28 p.

1974b. Data on the biology of lake trout from Great Bear and Great Slave lakes, Northwest Territories, 1973. Can. Fish. Mar. Serv. Data Rep. Ser. CEN/D-74-4: 39 p.

FALK, M.R., D.V. GILLMAN, and C.J. READ. 1980. Data on the walleye and other fish species from Mosquite Creek, Northwest

Territories, 1973-78. Can. Data Rep. Fish. Aquat. Sci. 186: v + 44 p.

FERGUSON, R.G., and A.J. DERKSEN. 1971. Migrations of adult and juvenile walleyes, *Stizostedion vitreum vitreum* in southern Lake St. Clair, Lake Erie and Connecting waters. J. Fish. Res. Board Can. 28: 1133-1142.

FORNEY, J.L. 1961. Year-class distribution of walleye collected by five types of gear. Trans. Am. Fish. Soc. 90(3): 308-11.

1963. Distribution and movement of marked walleye in Oneida Lake, New York. Trans. Am. Fish. Soc. 92(1): 47-52.

HATFIELD, C.T., J.N. STEIN, M.R. FALK, and C.S. JESSOP. 1972a. Fish resources of the Mackenzie River Valley. Interim Rep. 1. Vol. 1. Environ. Can. Fish. Serv. Winnipeg, Man. 247 p.

HATFIELD, C.T., J.N. STEIN, M.R. FALK, C.S. JESSOP, and D.N. SHEPHERD. 1972b. Fish resources of the Mackenzie River Valley. Interim Rep. 1. Vol. II. Environ. Can. Fish. Serv. Winnipeg, Man. 287 p.

HEALEY, M.C., and C.W. NICOL. 1975. Fecundity comparisons of various stocks of lake whitefish, *Coregonus clupeaformis*. J. Fish. Res. Board Can. 32: 404-407.

HOKANSON, K.E.F. 1977. Temperature requirements of some percids and adaptions to the seasonal temperature cycle. J. Fish. Res. Board Can. 34: 1524-1550.

JESSOP, C.S., T.R. PORTER, M. BLOUW, and R. SOPUCK. 1973. Fish resources of the Mackenzie River Valley, Special Report: An intensive study of the fish resources of two mainstem tributaries. Environ. Can. Fish. Serv. for the Task Force on North. Oil Develop. Environ.-Social Program, North. Pipelines. 148 p.

JESSOP, C.S., K.T.J. CHANG-KUE, J.W. LILLEY, and R.J. PERCY. 1974. A further evaluation of the fish resources of the Mackenzie River Valley as related to pipeline development. Can. Task Force on North. Oil Develop. Environ.-Social Program North. Pipelines Rep. 74-7: 95 p.

JESSOP, C.S., and J.W. LILLEY. 1975. An evaluation of the fish resources of the Mackenzie River Valley based on 1974 data. Can. Fish. Mar. Serv. Tech. Rep. Ser. CEN/T-75-6: 97 p.

JOHNSON, F.H. 1971. Numerical abundance, sex ratios, and size-age composition of the walleye spawning run at Little Cut Foot Sioux Lake, Minnesota, 1942-69. Minn. Dep. Nat. Resour. Sect. Fish. Invest. Rep. 315: 9 p.

JOHNSON, L. 1975. Distribution of fish species in Great Bear Lake, Northwest Territories, with reference to zooplankton, benthic invertebrates and environmental conditions. J. Fish. Res. Board Can. 32(1): 1989-2004.

MILLER, R.B. 1947. Great Bear Lake, p. 31-44. *In*: North West Canadian fisheries surveys in 1944-1945. Bull. Fish. Res. Board Can. 72.

MOSHENKO, R.W., L.W. DAHLKE, and G. LOW. 1978. Data from the commercial fishery for lake whitefish, *Coregonus clupeaformis* (Mitchill), on Great Slave Lake, Northwest Territories. Can. Fish. Mar. Serv. Data Rep. 101: v + 30 p.

MOSHENKO, R.W., and G.W.G. McGREGOR. 1978. Data on the Experimental Commercial Fishery at Cedar Lake, Manitoba, 1973. Man. Dep. North. Affairs Ren. Resour. Transport. Serv. Fish. Manage. Branch MS Rep. 78-62: 63 p.

MRAZ, D. 1968. Recruitment, growth, exploitation and management of walleyes in southeastern Wisconsin lakes. Wis. Dep. Nat. Resour. Tech. Bull. 40: 38 p.

NIEMUTH, W., W. CHURCHILL, and T. WIRTH. 1962. The walleye, its life history, ecology and management. Wis. Conserv. Dep. Publ. 227: 14 p.

OLSON, D.E. 1958. Statistics of a walleye sport fishery in a Minnesota Lake. Trans. Am. Fish. Soc. 87: 52-72.

OLSON, D.E., D.H. SCHUPP, and V. MACINS. 1978. An hypothesis of homing behavior of walleyes as related to observed patterns of passive and active movements, *In* R.L. Kendall (ed.) Selected coolwater fishes of North America Am. Fish. Soc. Spec. Publ. 11:52-57.

PAYNE, N.R. 1964. The life history of the walleye, *Stizostedion vitreum vitreum*, (Mitchill) in Bay of Quinte. M.A. Thesis, Univ. Toronto, Toronto, Ont. 40 p.

PRIEGEL, G.R. 1968. Winnebago studies. Annual progress report for the period January 1-December 31, 1967. Wis. Dep. Nat. Resour. Annu. Prog. Rep. 1967: 24 p.

1969. Age and growth of the walleye in Lake Winnebago. Wis. Acad. Sci. Arts Lett. 57: 121-133.

1970. Reproduction and early life history of the walleye in the Lake Winnebago Region. Wis. Dep. Nat. Resour. Tech. Bull. 45: 105 p.

RAWSON, D.S. 1947. Great Slave Lake, p. 45-85. *In* North West Canadian fisheries surveys in 1944-1945. Bull. Fish. Res. Board Can. 72.

1951. Studies of the fish of Great Slave Lake. J. Fish. Res. Board Can. 8: 207-240.

1957. The life history and ecology of the yellow walleye, *Stizostedion vitreum*, in Lac la Ronge, Saskatchewan. Trans. Am. Fish. Soc. 86: 15-37.

REGIER, H.A., V.C. APPLEGATE, and R.A. RYDER. 1969. The ecology and management of the walleye in western Lake Erie. Great Lakes Fish. Comm. Tech. Rep. 15: 101 p.

RICKER, W.E. 1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Board Can. 119: 300 p.

ROBSON, D.S., and D.G. CHAPMAN. 1961. Catch curves and mortality rates. Trans. Am. Fish. Soc. 90(2): 181-189.

SCHNEIDER, J.C., P.H. ESCHEMEYER, and W.R. CROWE. 1977. Longevity, survival and harvest of tagged walleyes in Lake Gogebic, Michigan. Trans. Am. Fish. Soc. 106: 566-568.

SCHUPP, D.H. 1972. The walleye fishery of Leech Lake, Minnesota. Minn. Dep. Nat. Resour. Invest. Rep. 317.

SCOTT, W.B., and E.J. CROSSMAN. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184: 966 p.

SMITH, L.L., L.W. KREFTING, and R.L. BUTLER. 1952. Movements of marked walleye, *Stizostedion vitreum vitreum* (Mitchill), in the fishery of the Red Lakes, Minnesota. Trans. Am. Fish. Soc. 81: 179-196.

SNEDECOR, G.W., and W.G. COCHRAN. 1968. Statistical methods. The Iowa State University Press, Ames, IA. 593 p.

STEIN, J.N., C.S. JESSOP, T.R. PORTER, and K.T.J. CHANG-KUE. 1973a. Fish resources of the Mackenzie River Valley. Interim Rep. II. Environ. Can. Fish. Serv. for the Task Force on North. Oil Develop. Environ.-Social Program, North. Pipelines. 260 p.

1973b. An evaluation of the fish resources of the Mackenzie River Valley as related to pipeline development. Vol. I. Task Force on North. Oil Develop. Environ.-Social Program North. Pipelines Rep. 73-1: 121 p.

STOUDT, J.H. 1939. A study of the migration of the wall-eyed pike, *Stizostedion vitreum*, in waters of the Chippawa National Forest, Minnesota. Trans. Am. Fish. Soc. 68: 163-169.

TOPOLNISKI, D. 1975. Northwest Territories recreational fishery, 1974-1975 statistics. Can. Dep. Environ. Fish. Mar. Serv. Winnipeg, Man. Unpubl. Rep. 27 p.

WOLFERT, D.R. 1963. The movements of walleyes tagged as yearlings in Lake Erie. Trans. Am. Fish. Soc. 92: 414-420.

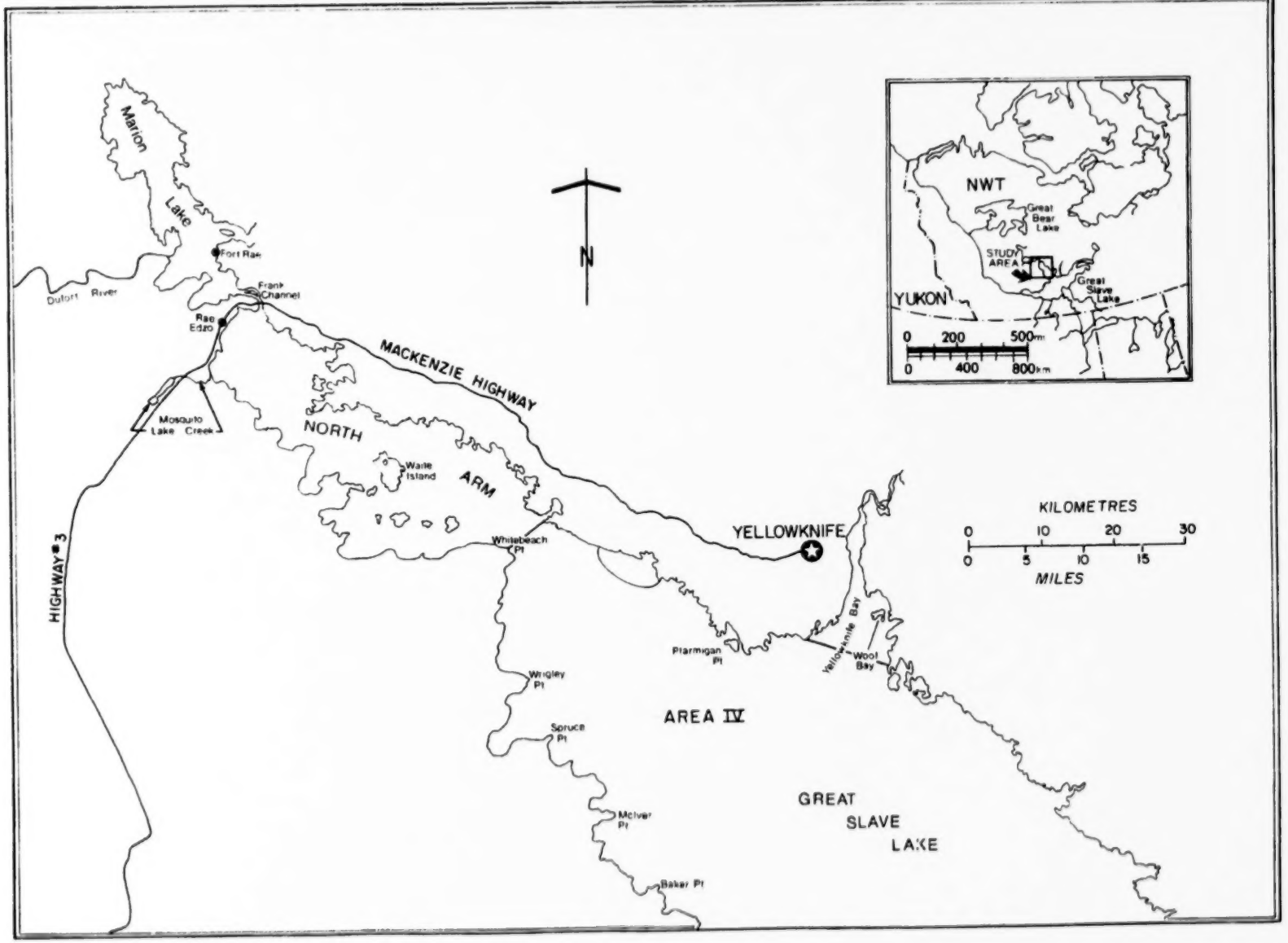

Fig. 1. Map of the North Arm of Great Slave Lake showing the location of Mosquito Creek.

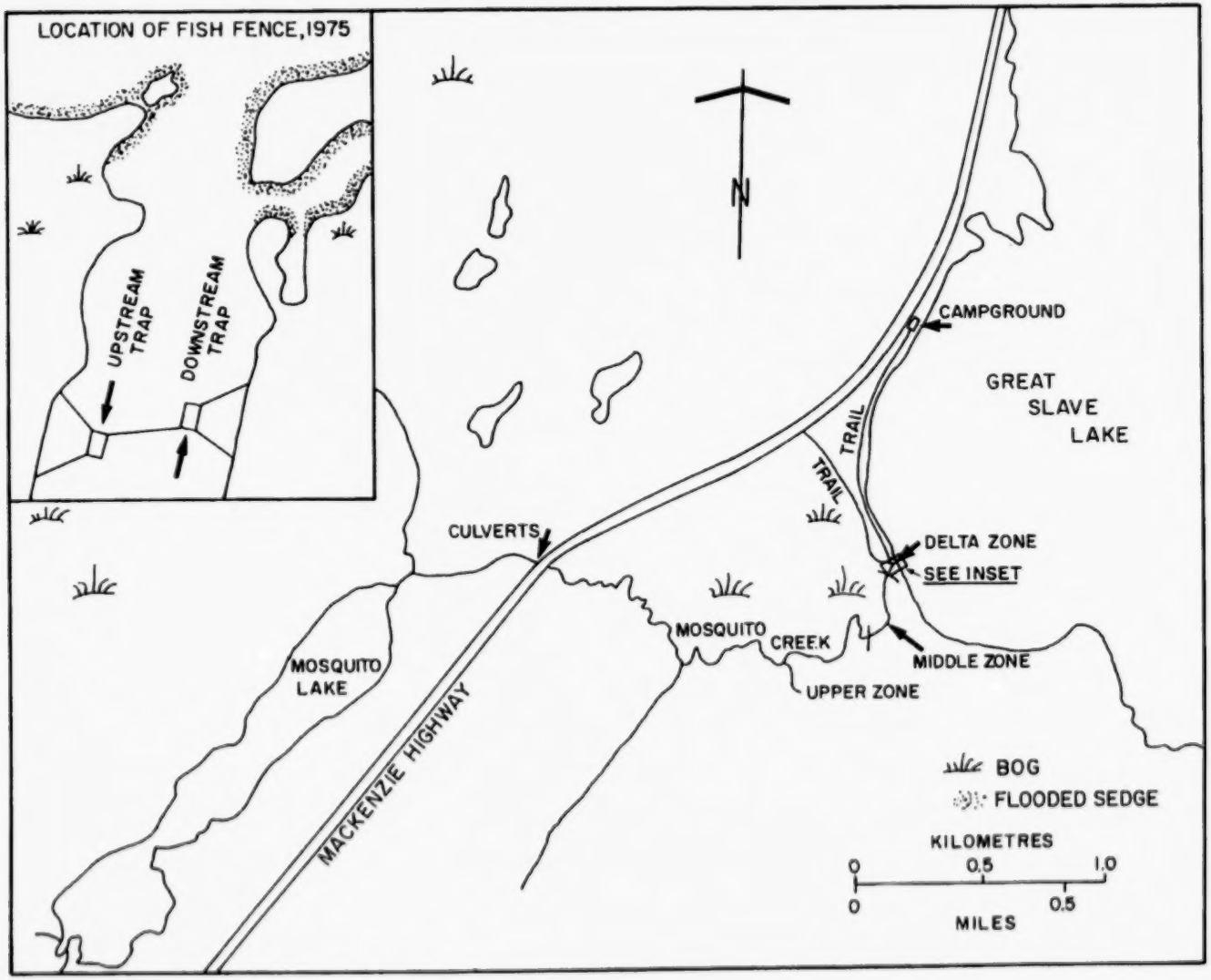

Fig. 2. Map of Mosquito Creek and immediate vicinity showing the fish fence location.

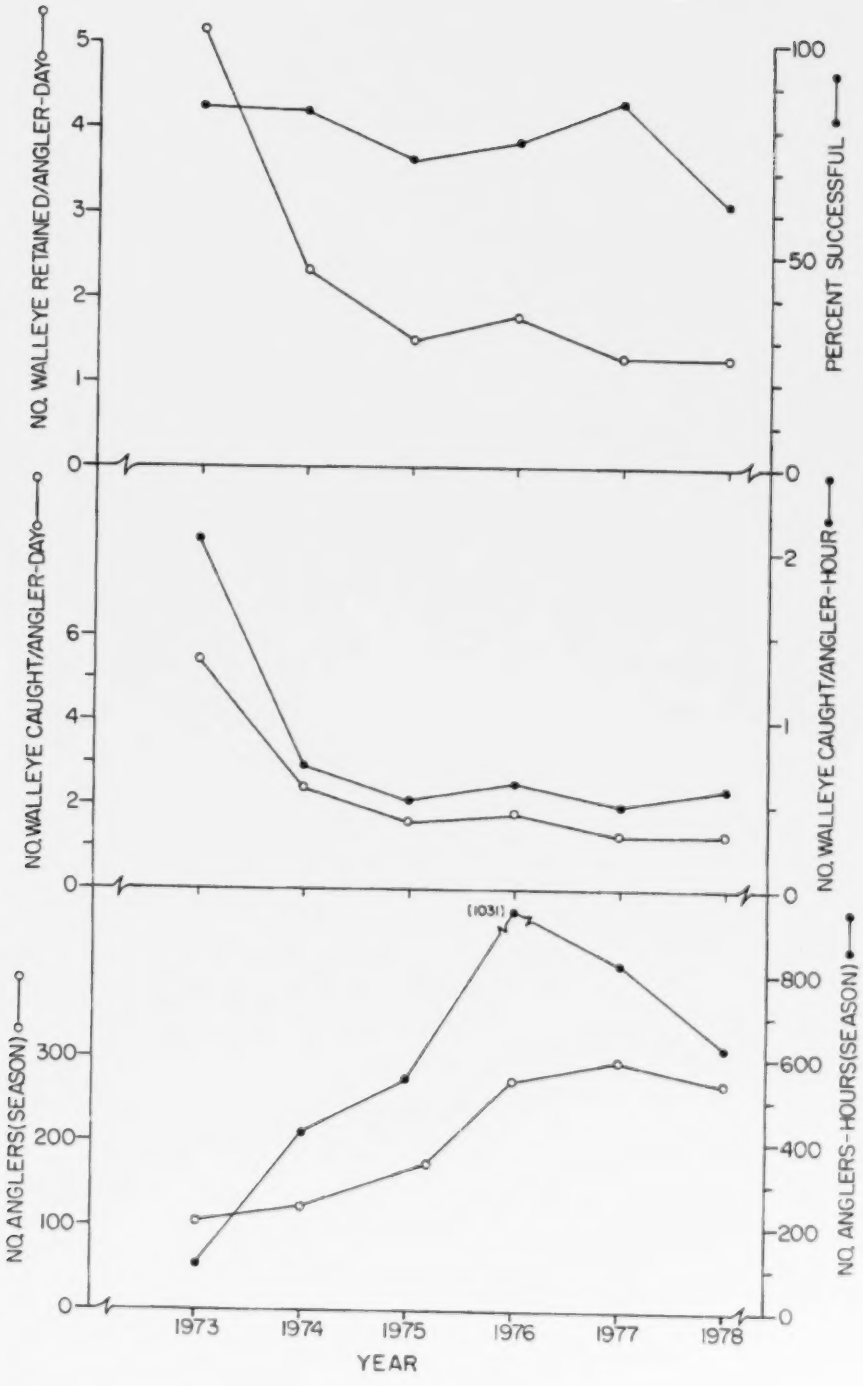

Fig. 3. Comparison of creel census results by year from Mosquito Creek, 1973-78.

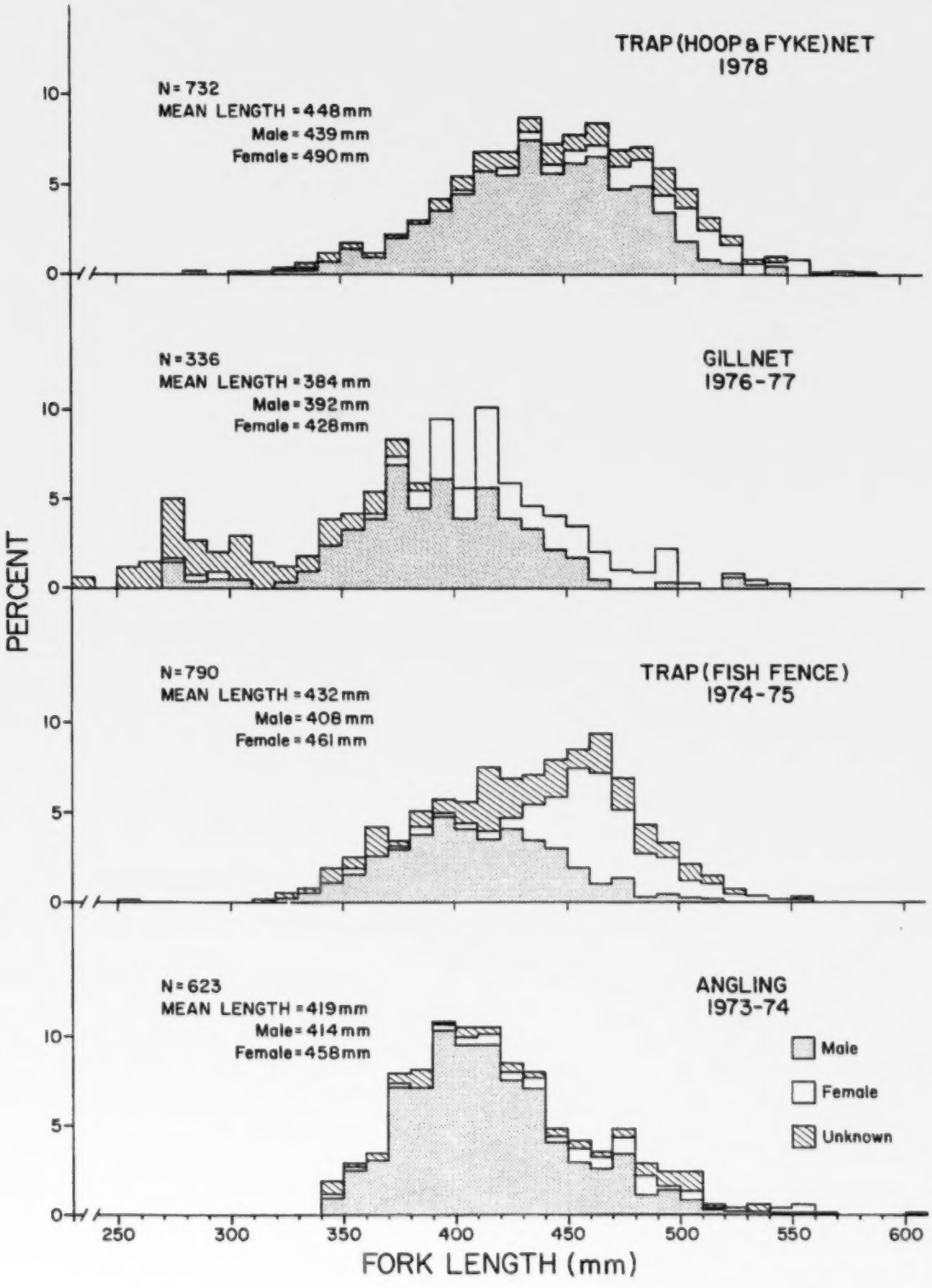

Fig. 4. Length-frequency distributions by capture method for walleye from Mosquito Creek, 1973-78.

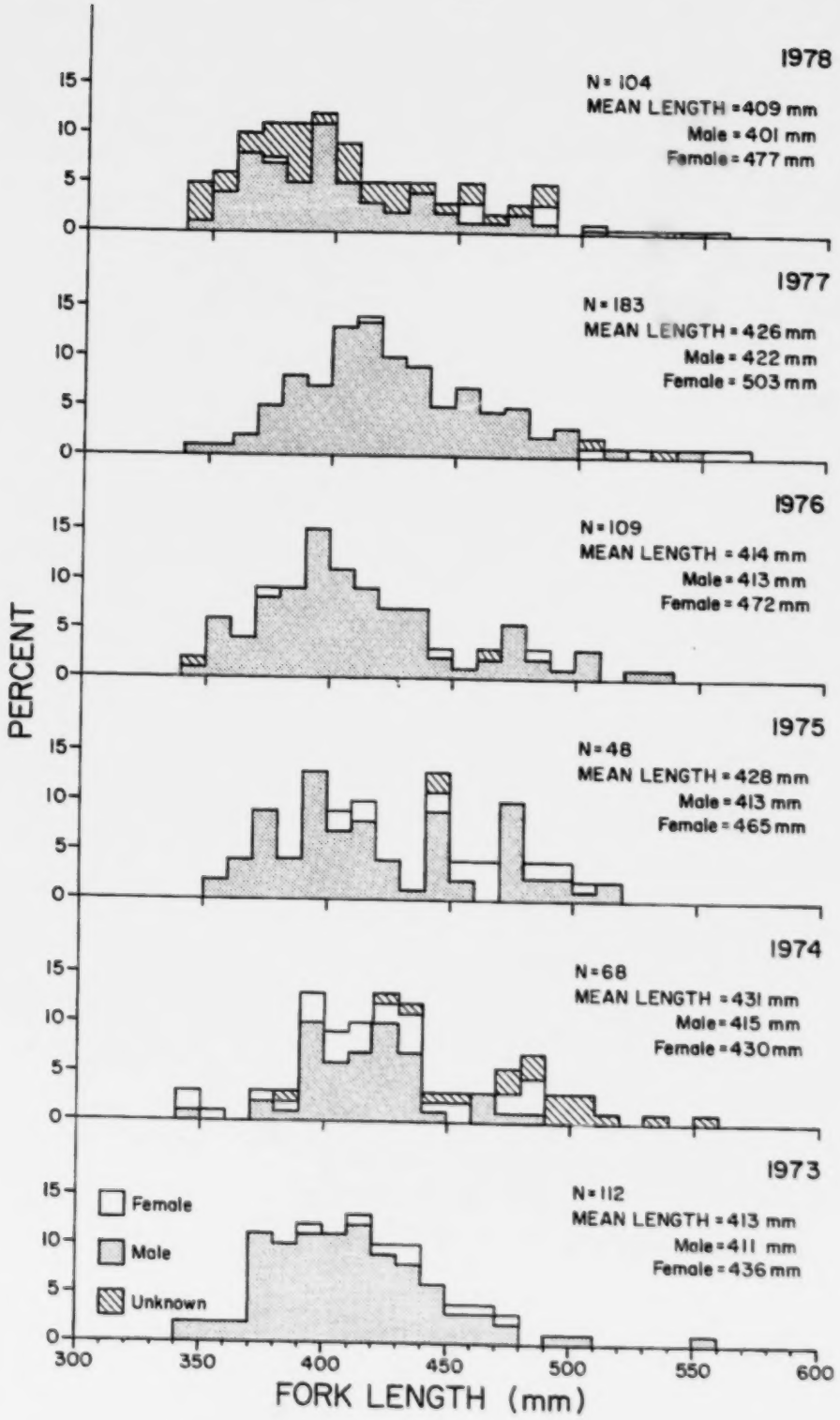

Fig. 5. Length-frequency distributions for walleye caught by angling from Mosquito Creek, 1973-78.

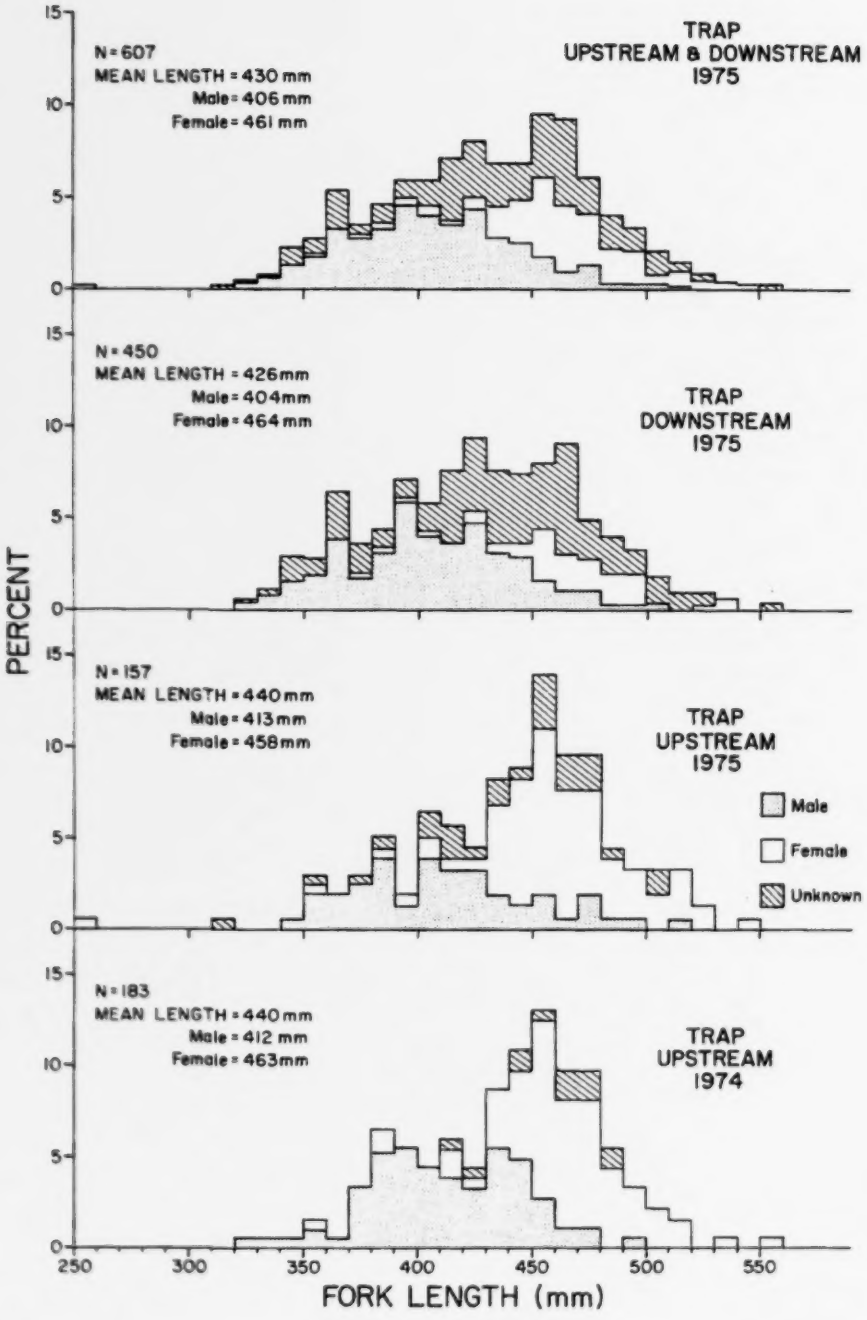

Fig. 6. Length-frequency distributions for walleye caught by the fish fence from Mosquito Creek, 1974-75.

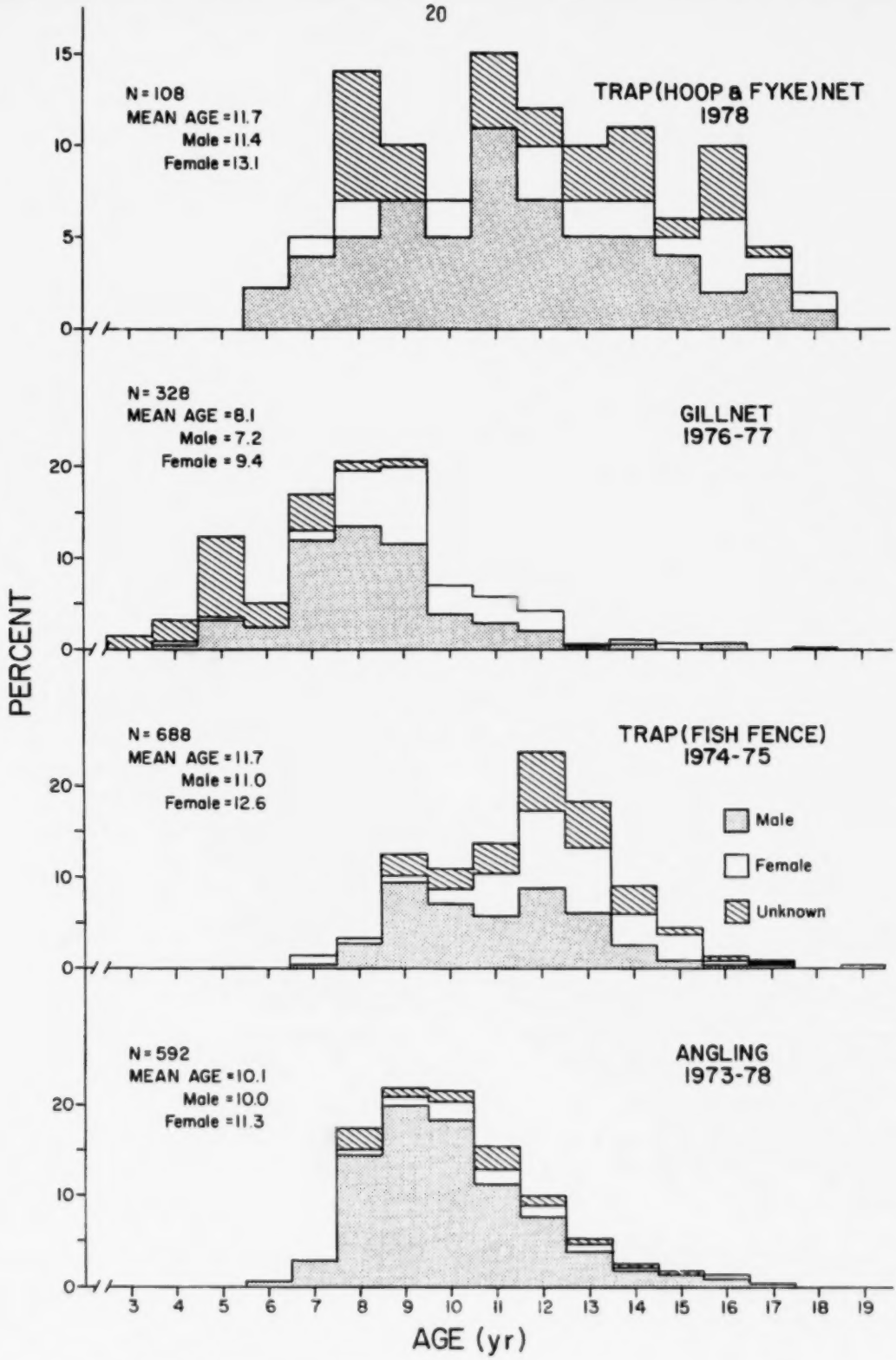

Fig. 7. Age-frequency distributions by capture method for walleye from Mosquito Creek, 1973-78.

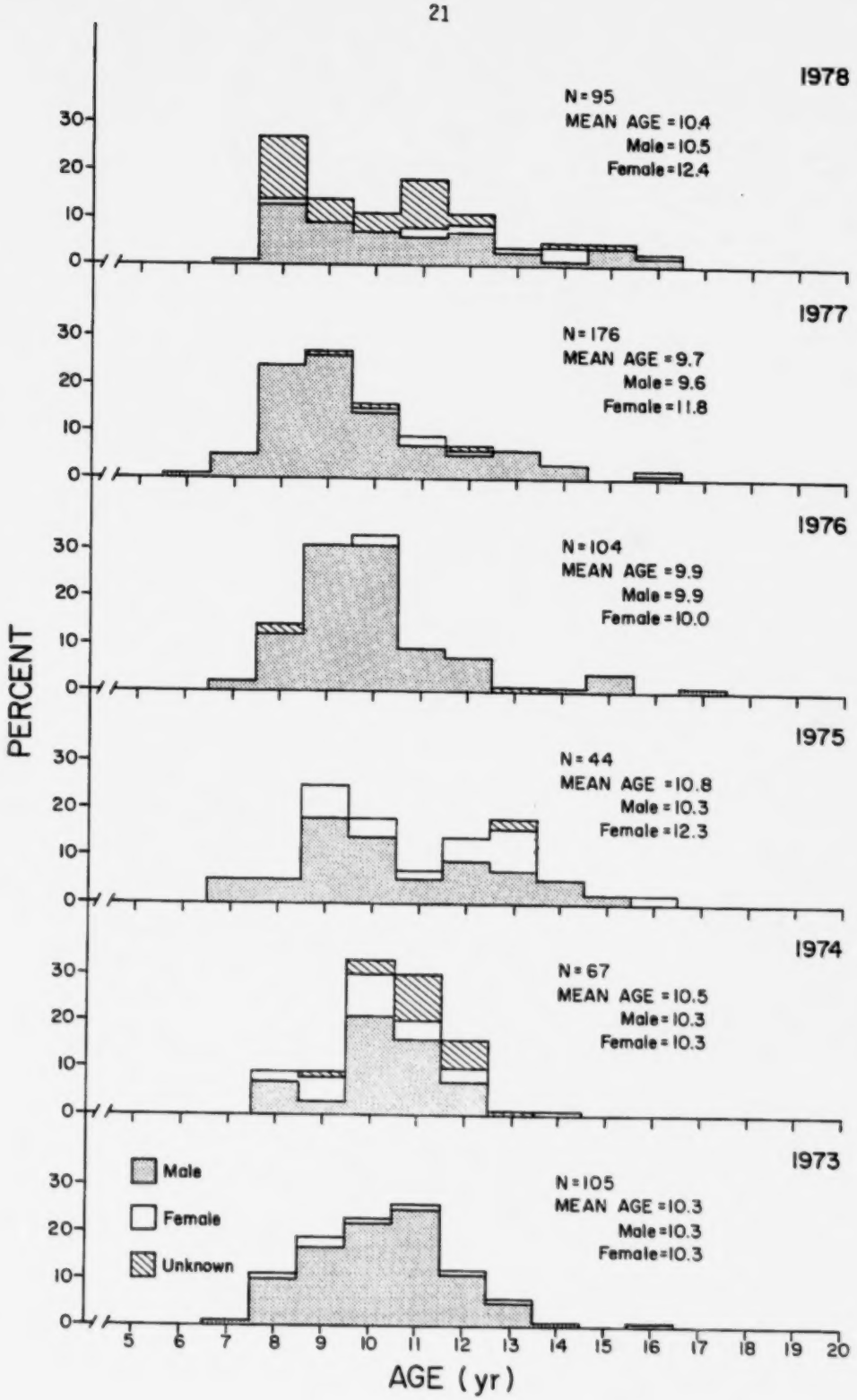

Fig. 8. Age-frequency distributions for walleye caught by angling from Mosquito Creek, 1973-78.

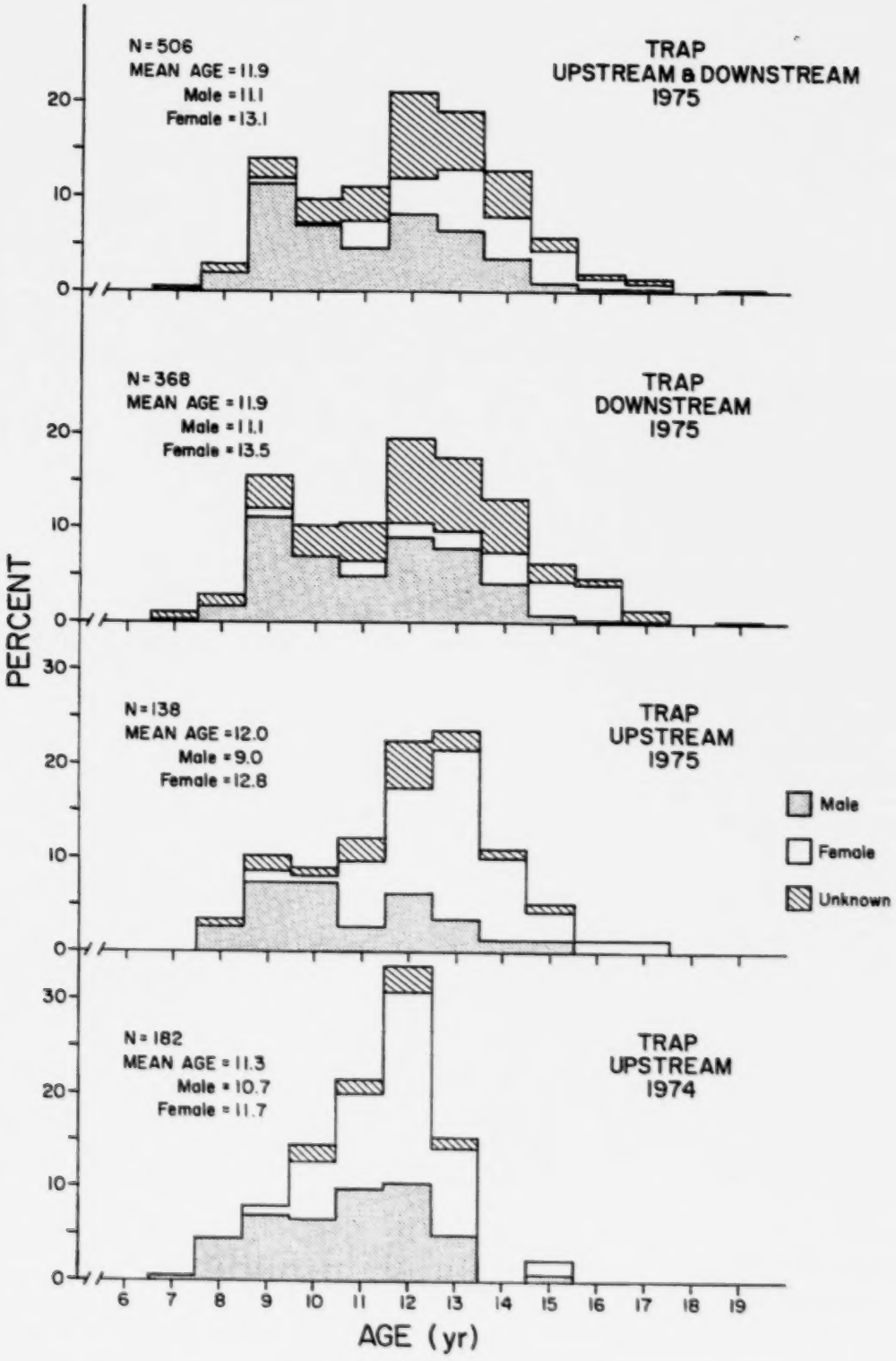

Fig. 9. Age-frequency distributions for walleye caught by the fish fence from Mosquito Creek, 1974-75.

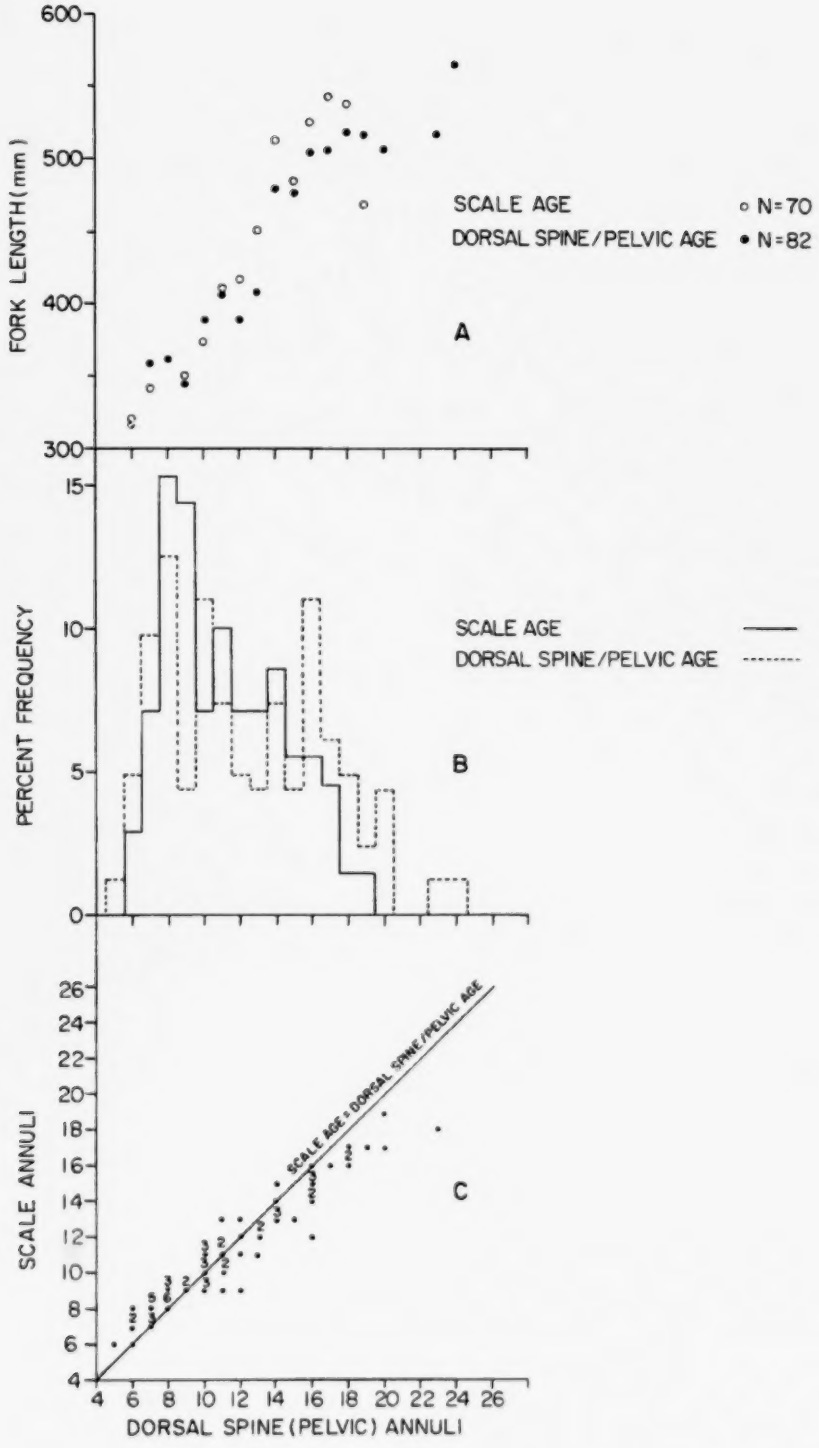

Fig. 10. Comparison of scale age to dorsal spine/fin ray age for walleye from Mosquito Creek, 1978.

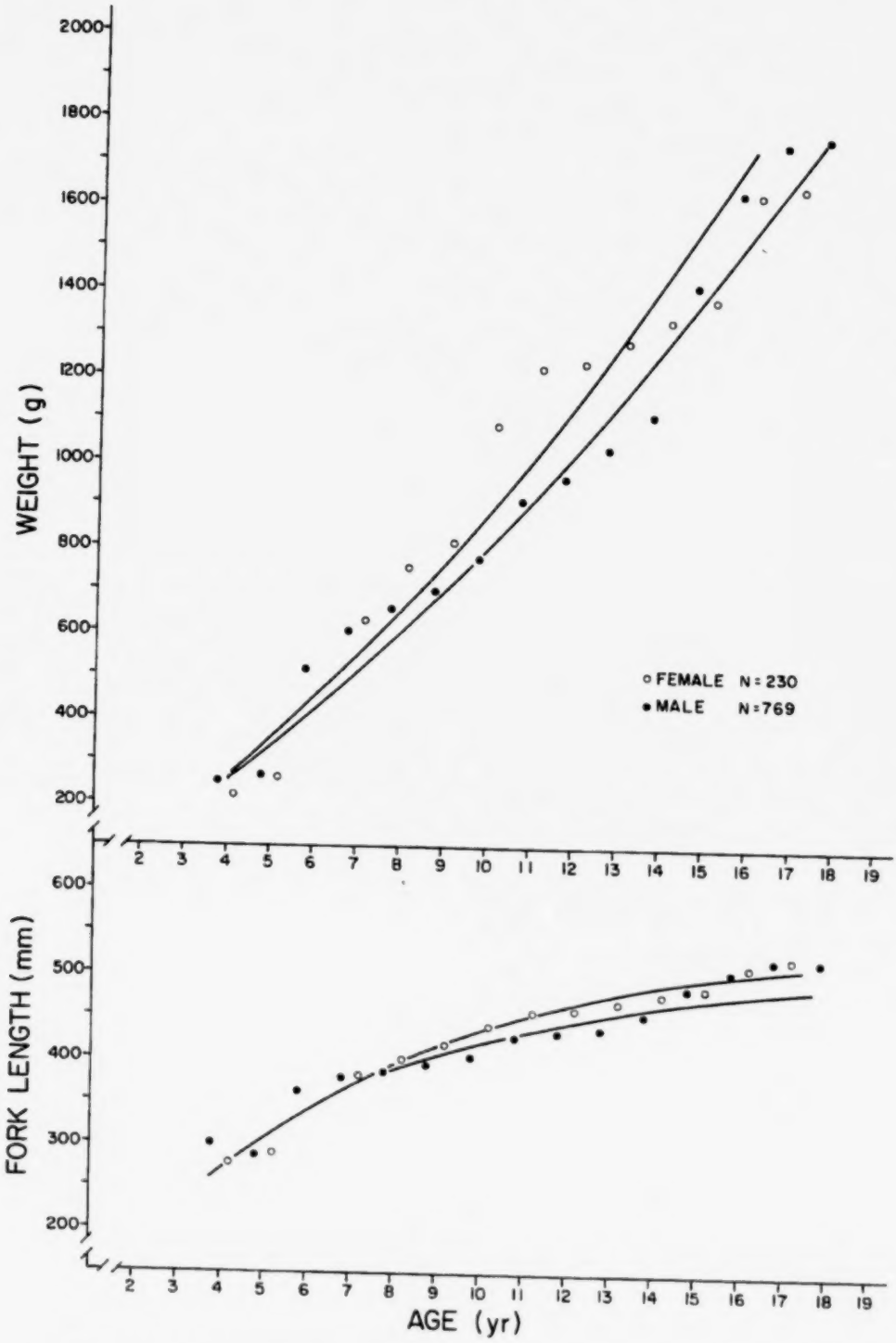

Fig. 11. Comparison of growth curves for male and female walleye from Mosquito Creek, 1973-78 (Fitted by eye).

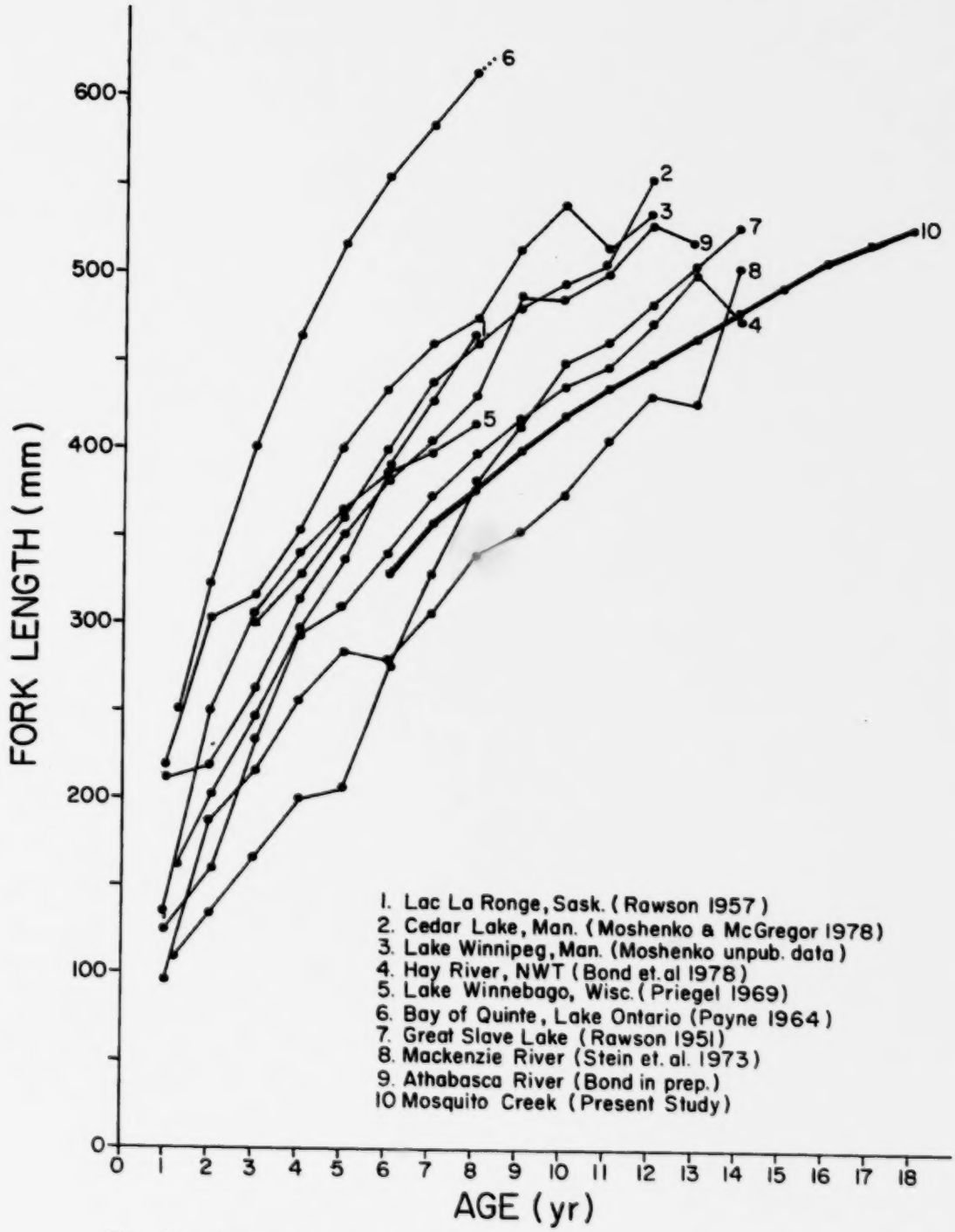
FORK LENGTH (mm)
AGE (yr)
0
100
200
300
400
500
600
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1. Lac La Ronge, Sask. (Rawson 1957)
2. Cedar Lake, Man. (Moshenko & McGregor 1978)
3. Lake Winnipeg, Man. (Moshenko unpub. data)
4. Hay River, NWT (Bond et.al 1978)
5. Lake Winnebago, Wisc. (Priegel 1969)
6. Bay of Quinte, Lake Ontario (Payne 1964)
7. Great Slave Lake (Rawson 1951)
8. Mackenzie River (Stein et. al. 1973)
9. Athabasca River (Bond in prep.)
10 Mosquito Creek (Present Study)

Fig. 12. Comparison of the growth curve of walleye (sexes combined) from Mosquito Creek, 1973-78, to other walleye populations in North America.

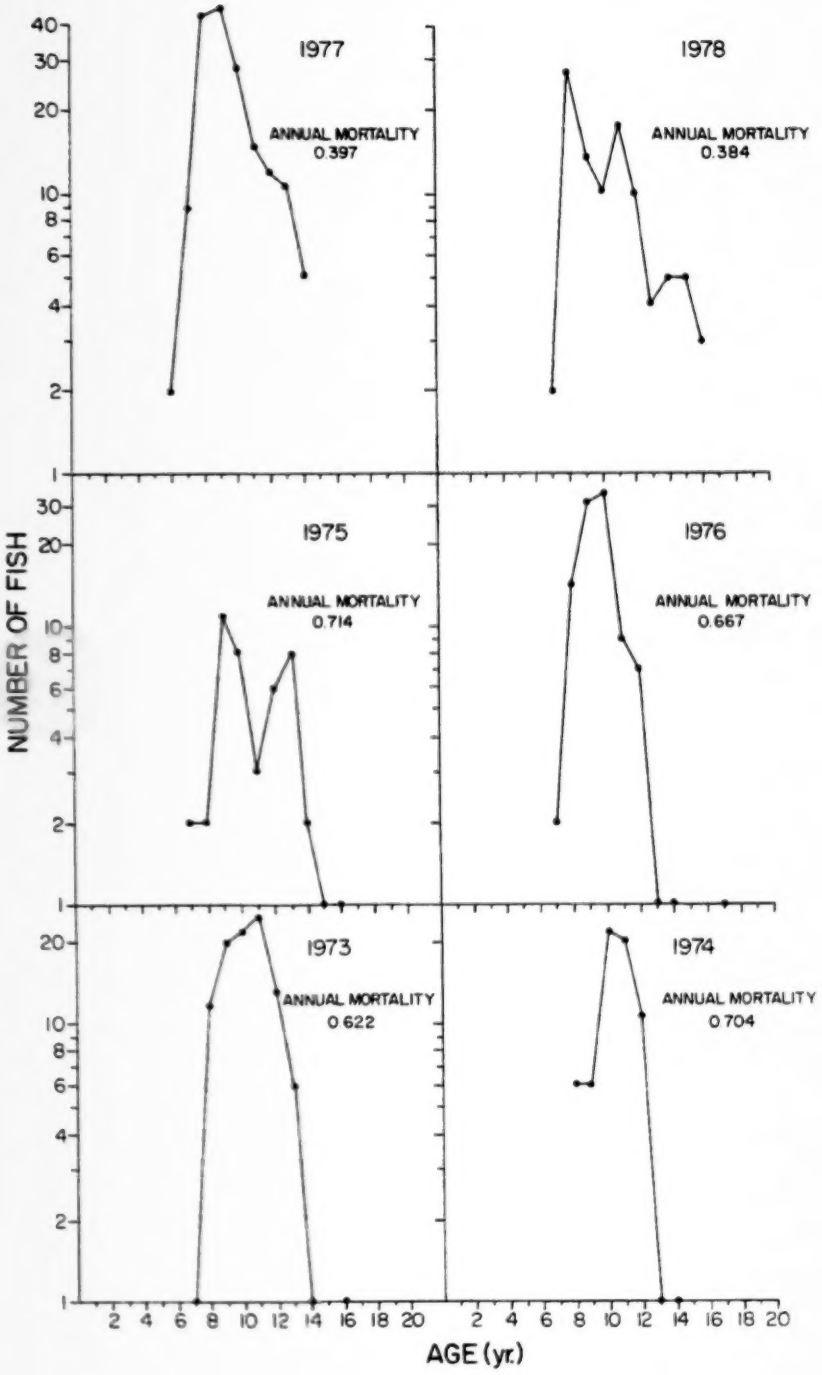

Fig. 13. Catch curves and annual mortality rates for walleye caught by angling from Mosquito Creek, 1973-78.

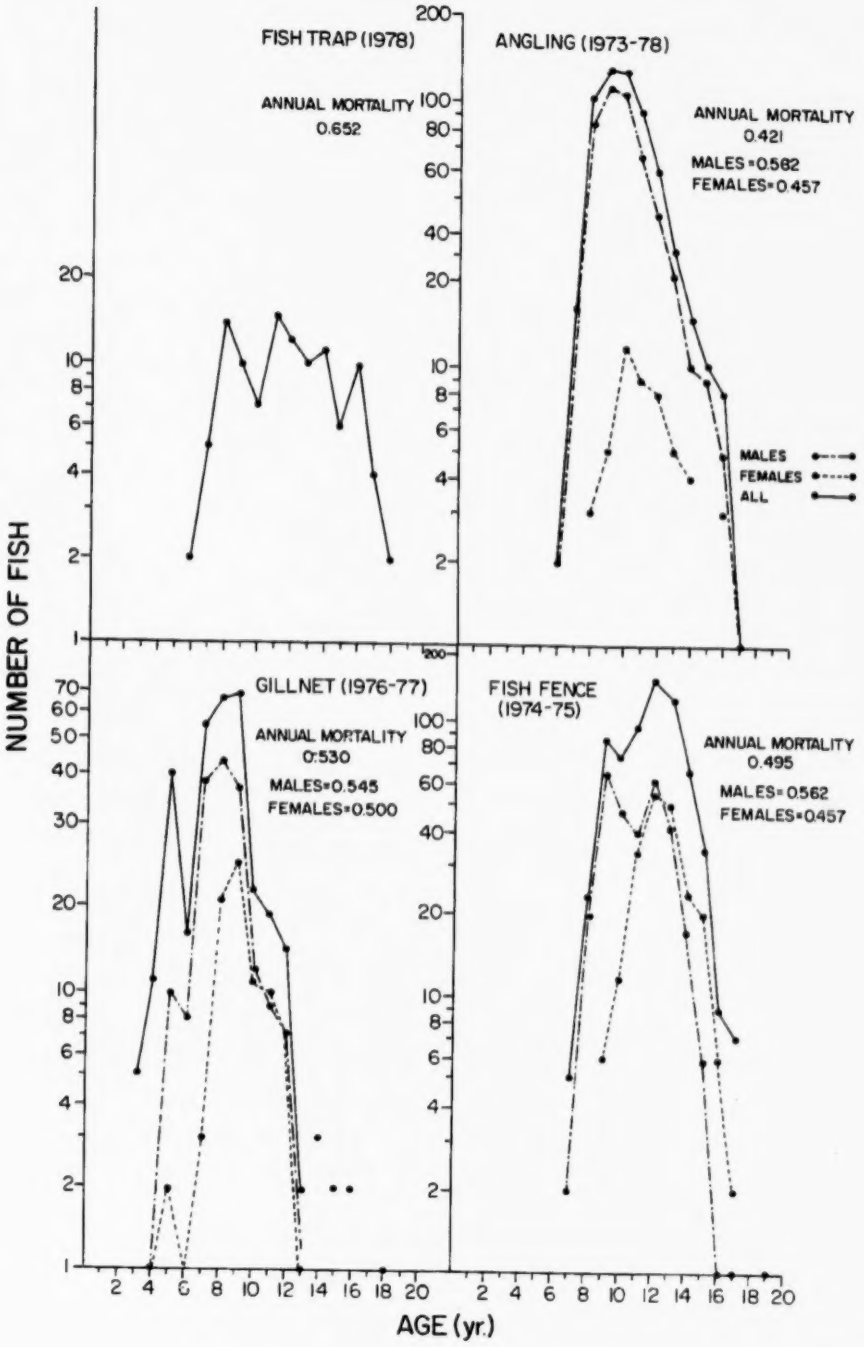

Fig. 14. Catch curves and annual mortality rates by capture method for walleye from Mosquito Creek, 1973-78.

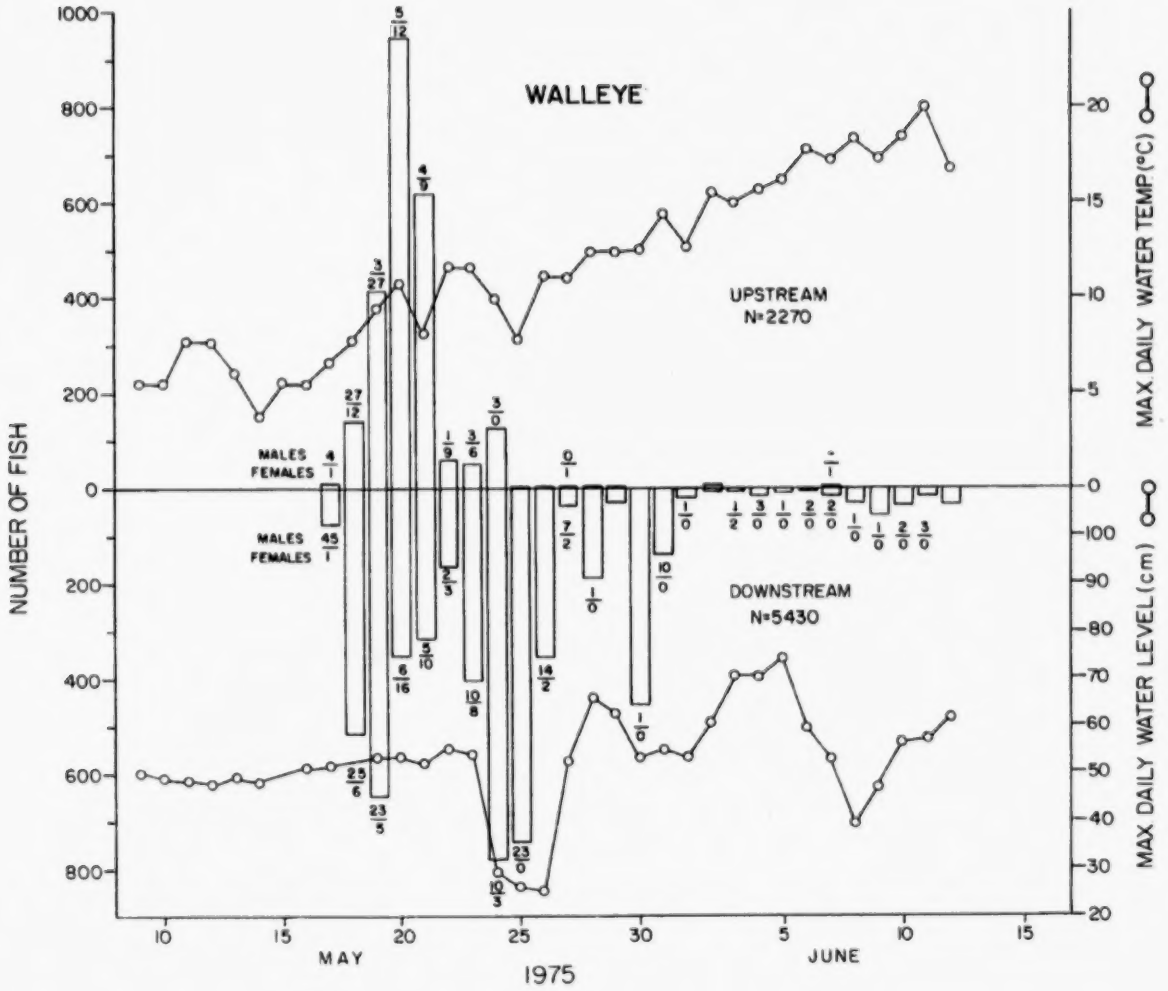

Fig. 15. Upstream and downstream movements of walleye in Mosquito Creek as determined by fish fence counts, 17 May to 12 June, 1975.

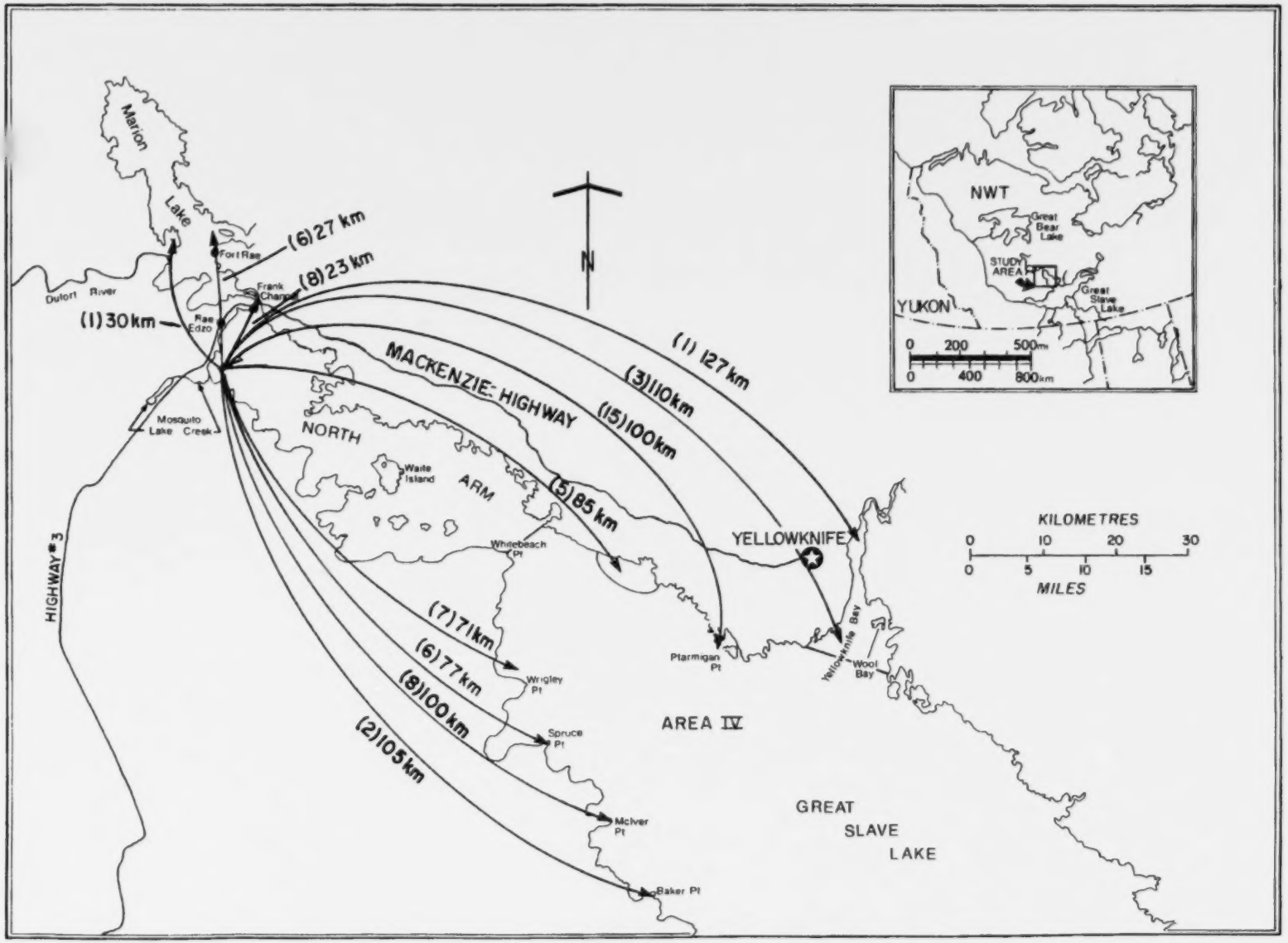

Fig. 16. Distribution and apparent movement patterns of mature walleye in the North Arm of Great Slave Lake as determined from walleye tagged in Mosquito Creek, 1973-78.